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VOL. I NO. 1

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

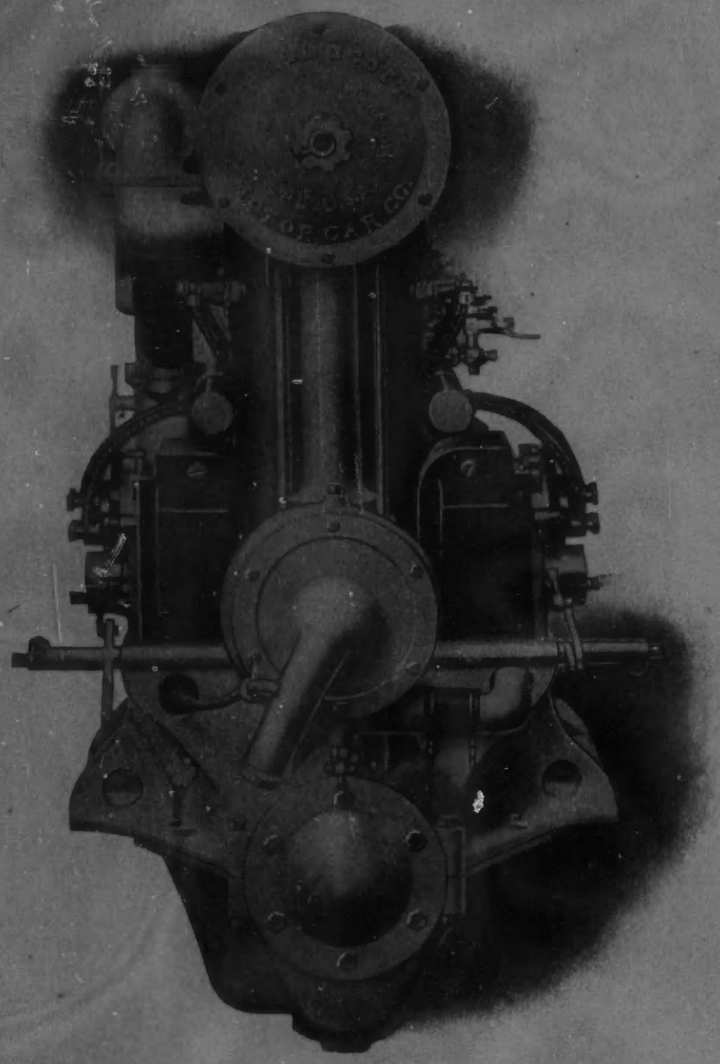
JULY 1917

FORMERLY THE S.A.E. BULLETIN

SOCIETY OF AUTOMOTIVE ENGINEERS INC.

29 WEST 39TH STREET NEW YORK

Non-Gran in the Hall-Scott Motor



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Look over the specifications of any of the fine motors built in America and you will find Non-Gran Bushings at those important points where wear would be fatal and where resistance to wear is therefore all important.

It makes no difference where these motors are built—New York, New Jersey, Ohio, Indiana, Michigan, Illinois, Wisconsin or California—their wear-subjected, non-adjustable bushings come from Berwyn, because in Non-Gran Bronze is found correct and adequate quality and the certainty of maintained uniformity.

American Bronze Company

Berwyn **Pennsylvania**

HIGH SPEED
NON-GRAN
BEARING BRONZE

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

Vol. I July, 1917 No. 1

The SEMI-ANNUAL MEETING OF THE SOCIETY

THE 1917 Semi-Annual Meeting of the Society, held June 26 at the Bureau of Standards, Washington, was characterized by record-breaking attendance and by the keenest interest in aviation and in the other subjects discussed. Every branch of the automotive industry was represented, this including the newly affiliated stationary gas-engine group. The members in attendance at the meeting evidenced deep realization of the stern work ahead and showed the most intense determination to find out in just what way they could best serve the Nation in carrying out that work.

They were met more than half way by the authorities in Washington. From the moment Secretary of Commerce Redfield welcomed them at the Bureau of Standards, through the consideration of an immense amount of standardization work, during the recitals by English and French aviators of the technical demands on their ingenuity, and concluding with the stirring address by Secretary of War Baker in which he called on each and every one to stand ready to do his part, as the nation needed him, in carrying on this "internal-combustion engine" war,—in fact, during two days of the liveliest activities, the members of the Society at every turn learned of the faithful and arduous work being done at Washington, and were as one in displaying the splendid unity of the S. A. E. organization.

The meeting of the Standards Committee, held all day Monday the 25th at the Bureau of Standards, was the first official event. A large number of Division reports were accepted by the Standards Committee. These reports, together with the discussion of them, are given in full on page 40 of this issue. During the morning session the Society was honored by a visit of Secretary W. C. Redfield of the Department of Commerce. Secretary Redfield, upon being introduced by Chairman John G. Utz, spoke in part as follows:

Remarks by Secretary Redfield

"I rejoice with all my heart in the bringing together in touch with this great scientific service of all the technical and scientific men of the country and of the industry. There has been altogether too much separation in the past. Now, I hope the day of getting together has begun, and that the process of getting together will go further and further. We are living in the midst of one of the greatest spectacles that the world has ever seen. We often say that democracies are naturally inefficient, because every man has the right to have his say, and commonly exercises his right, because out of discussion effectiveness can hardly come quickly. That is all true, but it is not all the truth. For the other truth is that when a legislative body acts by unanimous consent it is the most powerful, positive act of legislation that can be. Nothing can oppose it. And when a great democracy gets together by substantially unanimous consent it is the most menacing power to its enemies the world has ever seen.

"It is this process of American common consent that is going on in this country; it is going on to a perfectly amazing degree. I have never been more troubled in my whole life than by the inability to use half, yes, a quarter of the men in this country willing to contribute everything, to come here to Washington at their own cost and do anything to help along. It has been literally painful, because of the impossibility with any adequate speed to use these men as rapidly as they were ready to come to us and be used.

"I hunted a week to find a job adequate for a man who was the head of a factory employing six thousand men. He said that he had graduated from the managership to the superintendency and the presidency, and had now become chairman of the board of directors, and was ready to quit and come down here and do any old thing at his own cost. I got him a job at last. He will be some kind of a captain or other, and look after military equipment in the War Department.

"We are living sometimes too near to great things to realize their greatness. I would like to be able to come back thirty years hence and see this thing in its proper perspective. Automotive engineers, especially, have a part in the business of the day which is going to be one of the great factors. We are preparing to fight this war in the heavens above and the earth beneath and the waters under the earth; and we purpose, God willing, to control on behalf of the free men and the free peoples who travel in the heavens above and the earth beneath and the sea and all that is therein.

"We are getting ready here for this tremendous task. What a blessed thing it is for the friends of America across the water that the power of America, the power of the farmer, the power of the manufacturer, the power of the financier, is to be used as one mighty force to take their homeless people home and to make safe for them a place for all who are willing to be free, to make it safe to be what we have been here in America until now."

After the conclusion of the afternoon session the mem-

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bers were given an opportunity to inspect the various departments of the Bureau. Under the leadership of guides provided by the Bureau, visits were made to the strength of materials, heat, electrical, and other laboratories of interest to the members.

The June meeting of the Council was held at the Bureau on Monday afternoon. In the evening a meeting of the Sections Committee took place at the Munsey Building. The latter was devoted to a consideration of ways and means for strengthening the work of the Sections. On the same evening a meeting was held in the Munsey Building of engineers connected with motor-truck manufacturers to consider possibilities of standardizing parts for the new military trucks.

The business session on Tuesday morning, June 26, was called to order by President George W. Dunham. The first business was the report of Treasurer Herbert Chase, who stated that while the expenses of the Society had increased rapidly during the year the income had also increased at nearly the same rate, so that the policy laid down by the previous Council of investing receipts from initiation fees as a sinking fund, had been followed by the present Council. The Society has also made a subscription of twelve thousand dollars for Liberty Loan bonds.

REMARKS BY DOCTOR STRATTON

Dr. S. W. Stratton, director of the Bureau of Standards, then welcomed the members, and expressed the hope that the meeting would result in closer relations between the scientific work of the Bureau and the automotive industry. Director Stratton spoke in part as follows:

"We appreciate the great part that S. A. E. members are to play in the work that is before us now. Only by knowing their problems can the Bureau be useful to the engineers of the country; and then if the engineers simply meet here and get acquainted with our people, and if they get acquainted with the engineers, nine-tenths of the work in that direction is accomplished.

"Our experts in the Bureau who are interested in the lines which the S. A. E. is following are attending the meeting, and I am sure that out of it will grow a closer and closer relation between the scientific work of the Bureau and the automotive industry.

"I spent yesterday evening with the president of the Society of Mechanical Engineers, discussing how the Bureau could be made more useful to the mechanical engineers. He showed the greatest desire that the A. S. M. E. cooperate with the Bureau. I simply referred to the relations of the S. A. E. with the Bureau, and said that they might be taken as a model of the relations that we would like to have exist between the Bureau and all of the technical societies of the country; and it is the relation that does exist between the Bureau and most of them.

"The question often comes up as to whether the Bureau can establish standards. We have not a single duty of that kind described by law. Our function is to bring together the various people interested and then try to solve the unsolved problems in the laboratory. It is not the duty of the Bureau to set up standards in the automotive industry or in any other industry, but the Bureau can bring together the people interested, and especially the users that need the assistance, and the manufacturers and those who are to make the tests. In serving as intermediaries to bring people together we cannot help but see the points that need investigation, and we can assist here and there by an investigation of the material or the machine, or whatever it is.

"There is another reason why we are glad to see the S. A. E. this morning, and that is that perhaps I, as a member of the National Advisory Committee for Aeronautics, realize more than even the other members of the Bureau the important part that the Society is already taking in the development of the great aviation industry. The work began when a few automobile engineers, interested in the development of aviation engines, got together, and from that day to this—although it was almost a year ago—this group of men (the Aeronautic Engine Division of the S. A. E. Standards Committee), not large as it is now, has been meeting regularly. I have heard it said many times in the last three months that this war will probably be won by the use of airplanes and aircraft generally. Now, if there is one group of men more than all the others put together that will help this country place itself in a position to lead in aeronautic matters, it is this same group of men.

"I realize, and I think certain bureaus of the War and Navy Departments realize, that outsiders cannot appreciate the great assistance that the automotive industry is now rendering the Government. I cannot recall any other industry that has come to the front in such a solid unit and with one accord as has this industry. In a few years we will look back with great pride to the assistance that this Society has given the Government, and especially the group in this Society interested in the development of the aviation engine. We rarely ever discuss such matters in aviation circles, except that this Society, the way it works, the way it standardizes, is held up as an example of how the thing ought to be done. It is astonishing how much real energy is found in this group of young engineers."

The meeting enthusiastically adopted a motion proposed by Chairman Beecroft of the Meetings Committee to the effect that the courtesy of Doctor Stratton and of the Bureau of Standards in extending to the Society the use of the auditorium and other parts of the Bureau was appreciated.

The next business was a report by Councilor B. B. Bachman, acting as chairman of the Constitutional Committee appointed by the Council. Mr. Bachman reported that the committee recommended the adoption of the proposed constitutional amendment relating to a new standing committee of the Society to be called the Constitutional Committee. This amendment was printed on page 445 of the January BULLETIN, and has also been sent to all the Members, in accordance with the Constitution. It was voted to submit the amendment by letter ballot to the Members of the Society.

An amendment to Article C8 was proposed at the Annual Meeting of the Society (see page 445, January BULLETIN) and was also sent to all the Members. Mr. Bachman reported that the committee recommended that this amendment should not be adopted, but instead that Articles C8, C9, and C10 of the Constitution should be amended so that the word automobile, wherever it appeared, should be changed to be automotive. This change is made in order to conform with the change in name and scope of the Society. It was voted to approve these recommended changes in the Constitution for submission by letter ballot to the Members of the Society.

President Dunham then read his address, as given elsewhere in this issue. In the absence of Chairman R. O. Gill of the Membership Committee, Secretary Clarkson read a report showing that the total membership on June 1, 1916, was 1911, on Jan. 1 of this year 2121, and on June 1 of this year 2640 members of the Society. The membership on June 26, including enrolled students,

affiliate members, representatives, and applicants approved but not qualified, was 3030. In addition, over 1000 Section Associates are enrolled in the eight Sections of the Society.

According to the Constitution of the Society, three Members elected at the Business Session of each Semi-Annual Meeting, together with members elected by the Sections of the Society, make up the Nominating Committee. The following members were elected by the Society to serve on the Nominating Committee: H. W. Alden, H. G. Stoddard, and William G. Wall. The members elected by the Sections to serve on the committee follow: David Fergusson, Buffalo Section; K. H. Brown, Cleveland Section; L. D. Bolton, Detroit Section; F. E. Moskovics, Indiana Section; N. B. Pope, Metropolitan Section; G. W. Smith, Mid-West Section; E. R. Greer, Minneapolis Section; and W. H. Palmer, Jr., Pennsylvania Section. The By-Laws of the Society provide that this committee shall report previous to Oct. 1, giving the names of consenting nominees for offices next falling vacant. It is expected that the committee will make a complete report next month.

Chairman John G. Utz of the Standards Committee gave an illustrated lecture showing by charts the work done during the past year by the Standards Committee, and by photographs of the Council of the Society and of the members of the Divisions the men who had done it. These pictures were supplemented by a brief explanation, given by Chairman Utz, as to the work accomplished.

The reports of the Standards Committee were then presented, and practically all of them were accepted for submission to mail vote of the members of the Society.

The Professional Session held at the Bureau on Tuesday afternoon was opened by President Dunham with some remarks on the membership situation. Many of the members of the Society are now placing their entire time at the disposal of the government. The Society is doing its utmost to cooperate in every way in all automotive government activities. In order to do this most successfully it will be necessary to increase the membership. President Dunham therefore asked all those present at the meeting to promise to obtain a new member. A hearty response was made to his request, and all the members present agreed to get one new member, and more, if possible. Chairmen of several of the Sections also promised on behalf of their organizations to secure a number of new members.

Commander Seddon, Captain de la Grange, Mr. Sutphen and Mr. Horning then gave the technical papers printed in this issue. Mr. Sutphen presented a moving-picture film showing the assembly of submarine chasers in Canada, and also the methods of testing them. The films shown by Mr. Horning were of a farm tractor operated for hauling plows, harrows, and for other purposes, and of a tractor of the self-track laying type used as a military unit. Papers by Messrs. Sargent and Thomas were given by title, lack of time preventing their being discussed.

The Summer Meeting concluded with one of the largest dinners ever held by the Society and the first one held at a Summer meeting. The speeches relating to the aeronautic situation and to the war in general, as given by Secretary of War Baker, Edward A. Deeds of the Aircraft Production Board, Commander Seddon and Captain de la Grange, are given on page 32 of this issue.

PRESIDENTIAL ADDRESS
OF
GEORGE W. DUNHAM

FOR many years the Society of Automobile Engineers has met each June to discuss technical papers, transact routine business, and renew old friendship by participating in affairs devoted to pleasure and entertainment.

We now come together in the first meeting of the Society of Automotive Engineers, not for pleasure or profit, because such a purpose would not be fitting in these times, but in order that we may, at the center of our National life, express our loyalty and allegiance as a society and as individuals to our Government.

We come also that we may hear from prominent Government representatives and from authorities on the use of automotive apparatus in war, how we can fulfill our obligation to the nation most efficiently.

In these times we as automotive engineers have a duty to perform. Thousands of S. A. E. members have expressed their willingness to serve the nation, according to their ability and as may be determined by the Government.

The members of the Society, three thousand strong, and comprising practically all the leading automotive engineers of this country and many resident abroad, are experts in the design, building, operation and maintenance of all forms of automotive apparatus. Their experience therefore is such as to make them invaluable in virtually every activity connected with the prosecution of the war in which the country is at present engaged.

The work to be done by the S. A. E. members can be appreciated when we think of the thousands of motor trucks needed for transporting food, supplies and ammunition to our own troops and to those of our allies; the motorcycles that will be required for dispatch riders and motor truck companies; the passenger cars that will be needed for transporting officers and for innumerable other purposes; the airplanes we must build for the training of thousands of aviators and for fighting at the front; the motor-boats to be used for patrolling and averting the submarine menace; the tractors for moving field artillery; the farm-tractors that must be built and put into efficient operation in order to feed the civilized world; and the many other power equipments that are necessary.

It is only a year ago that the proposal was made for the merger of the automobile, aeronautic, tractor and marine engineers. The wisdom of this idea was quickly seen by the members of the various societies concerned, and as a result the Society of Automotive Engineers came into being on April 19 last. In addition, the National Gas Engine Association has voted that all its technical matters shall be taken up through a committee of the S. A. E., and many of the engineers connected with the N. G. E. A. company members are joining this Society. They certainly will be heartily welcome.

The new and greater S. A. E. was formed that the Government might be able to deal with one engineering organization instead of several, and that automotive engineering might be more rapidly advanced through better cooperation. The Society has been given many opportunities to serve the Government in the last few months, and, because of the very nature of its activities, perhaps to a greater extent than have any of the other national engineering societies.

A great deal of this governmental work has naturally been done through the Standards Committee of the Society, of which John G. Utz is chairman. The Truck Standards Division of this committee spent almost a year in the formulation of specifications for Class A and Class B military trucks. This work was carried on in conjunction with the Motor Transport Board of the War Department and with officers of the Quartermaster Corps. The completed specifications, which will be used in building the immense fleet of trucks necessary for the armies we will send abroad, are highly creditable to the members of the Truck Standards Division and of the Electrical Equipment, the Springs, the Engine, and the Transmission Divisions of the Standards Committee.

Other divisions of the Standards Committee have been in close touch with departments of the Government. The Aeronautic Division has been working with the Aviation Section of the Signal Corps and with the Navy Department in the standardization of detailed parts for airplanes. Although the aeronautic industry is comparatively new, much has been accomplished by this division, and the work it is now doing is of such magnitude and importance that the division should have the undivided support of all, even those not directly interested.

The Tractor Division has brought about a new era of cooperation among the engineers of the tractor industry, who are already enthusiastically taking up the work of standardization. The division has also been in close touch with the U. S. Department of Agriculture in devising ways and means to increase food production.

The Marine Division has been most active in the standardization of parts in its field and much can be expected from it. This Division has been in close cooperation with the Navy Department.

MEMBERS IN THE SERVICE

A large number of members of the Society have already entered the service of the Government and many more are ready immediately they are needed. It is noteworthy that six past-presidents of the Society are taking prominent parts in Government work. Past-President Riker is a member of the Naval Consulting Board. Past-President Coffin, who did efficient work in connection with the Industrial Preparedness Committee of the Naval Consulting Board, is a member of the Advisory Commission of the Council of National Defense. He is also chairman of the Aircraft Production Board.

Past-President Souther is the senior officer of the Aircraft Engineering Division of the Aviation Section of the Signal Corps, with the rank of major. Past-President Marmon is doing engineering work with the Aircraft Engineering Division. Past-President Alden has been made a major in the Ordnance Officers' Reserve Corps. Past-President Van Dervoort is acting as a member of the Munitions Committee of the Council of National Defense.

Former Vice-President Zimmerschied is vice-chairman of the Automotive Transport Committee of the Council of National Defense. Former Vice-President William G. Wall is now a major in the Ordnance Officers' Reserve Corps. Vice-President Vincent has been doing work of the greatest importance in connection with aeronautic matters at the Bureau of Standards. The members of the Council are spending a considerable part of their time at Washington, and your president is the civilian member of the Board for Motorizing Field Artillery at the Bureau of Ordnance.

The S. A. E. office, which has been established in Washington, has kept in touch with the Government departments in order to be of service whenever possible. This service has been the supplying of names of men to act in various capacities and assisting the Government to make the best use of the resources of the Society. Many of our members will be required to do active duty of an engineering nature in the Government service. Others, however—and it is likely that these will form a large portion—will serve best by remaining at home in their usual occupations and by spending all their energy in the production of vehicles and apparatus to supply the needs of the war.

These members at home can naturally assist in carrying on the general work of the Society. The war will require even more rapid development of the industry than has been the case previously. More work must be done by the divisions of the Standards Committee. Engineering development must go on, and it will be necessary to present and discuss important technical papers in order to increase the efficiency for war purposes of all types of automotive apparatus.

To one familiar with the tractor industry the wonderful advancement from an engineering standpoint is obvious, but it must not be overlooked that the tractor is comparatively new and that it will be used by those unskilled in mechanical matters. There is great need of a strong movement to educate the consumer as to operation and maintenance, thus resulting in the elimination of much of the grief experienced in the early days of the automobile. One of the biggest problems to be solved by tractor engineers is the use of kerosene and other low-grade fuels.

We are prone to look upon the automobile as closely approaching its ultimate form, but there is much yet to do in the way of simplification. When we stop to realize that in the average automobile about a thousand pounds of car is required to the single passenger, we must admit that we are far from having solved the proper construction from the standpoint of weight.

There has been a feeling that suitable engines for battle-type airplanes cannot be produced in this country. What can be done elsewhere certainly can be accomplished here. It must be the prime effort of the aeronautic engineering members to make this condition a reality.

The motor-truck engineers are to be congratulated on their accomplishments. Much may be done by the still closer contact of the truck manufacturers, the truck assemblers and those engaged in the manufacture of engines, transmissions, axles and other parts, so that a greater uniformity of construction may result in an improved mechanism.

Society Committee Activities

The administrative committees of the Society have been of great assistance in carrying on the work during the year. The Finance Committee has given valuable advice in handling the funds of the Society. Our operating expenses have increased on account of the unusual demands resulting from the war. In spite of this, how-

ever, the Council has felt that the work of the Society in cooperation with the Government must be carried on even if it is necessary to draw on reserve funds set aside in previous years.

In connection with the work of the Publication Committee, Part I of the 1917 Transactions is now under way and will soon be sent to each member of the Society. An important development in our publication affairs will take place in July, when the first issue of THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS will appear. The S. A. E. BULLETIN has been issued for several years, but on account of the increased activities of the Society it has become necessary to enlarge it. The name has also been changed, so that it will be characteristic of our new organization. The S. A. E. JOURNAL will be issued in the standard technical size and will be a credit to the Society and an efficient method of carrying out its object.

The Meetings Committee has done exceptionally good work in preparing for the meeting we are holding today. It has planned all the details that make this the most eventful meeting ever held by the Society; and this in the face of many changes of plans made necessary on account of war conditions.

Increase in Number of Sections

Two new Sections have been added during the year, one at Buffalo and the other at Minneapolis. The latter will devote its attention mainly to tractor engineering problems. A large number of meetings have been held by the various Sections during the year, at which many valuable technical papers have been presented and discussed.

The Council of the Society has appointed a Sections Committee, which will exercise general supervision over the work of the Sections. This committee is constituted of three members designated by the Council and of the chairmen of all the Sections. A number of problems are under consideration by the Sections Committee, the solution of which will, it is hoped, increase the working efficiency of the various local organizations of the Society.

The work of the Sections is of the greatest importance in the proceedings of the parent body. There is an opportunity for forming new sections in several automotive engineering centers. No better work can be done by the members of the Society who are not located so that they can readily attend meetings of the present sections than in forming new sections and in obtaining the necessary addition to the membership of the Society to carry on the work of such sections.

More Members Needed

The membership of the Society has increased almost 30 per cent during 1917. This is due in great part to the good work of the Membership Committee. During April this committee carried on a special membership increase program. A large number of the new members are specially interested in the aeronautic, tractor and marine engineering work. There are still many men in the automotive industries who are qualified for membership and who would not only be benefited by such membership but would be able to render valuable assistance in carrying on the work of the Society. Each member is therefore urged to do his best to get such men into the organization. There are now about 3000 members, so that there is work for all of us to do in arriving at the mark of 5000, which was mentioned by President Huff in his address given at the 1916 Summer Meeting, and which should be reached by the first of the coming year.

The Society of Automotive Engineers is an organization of great accomplishments and wonderful possibilities. Few among us will attempt to forecast the future of the aeronautic and the tractor industries, while great development in the automobile and marine fields is certain.

We are members of what is justly known as the livest and most progressive engineering society in the world. Every one of us should have the greatest pride in our organization, an organization conceived because of the great need of national preparedness and baptized in deep stress and turmoil of world warfare. When rest again settles on the earth, the Society will go forward, its members cultivating the arts of peace, just as they are now following those of war. Then will history record the founding of the Automotive Industry through the inspiration and patriotic devotion of a body of men who had called themselves automotive engineers.

PLANS FOR INSPECTION OF AERONAUTIC MATERIALS

THE advisory committee recently formed to suggest specifications and inspection methods for airplane materials, on behalf of the Aviation Section of the Signal Corps, met July 17 in the New York office of the Society. The work of the committee will be supervised by Major Souther of the Signal Corps. Those present were: F. G. Diffin (chairman), who has entered the Government service; W. H. Bassett, American Brass Co.; H. L. Green, Wright-Martin Aircraft Corp.; H. J. Horn, J. A. Roebling's Sons Co.; Chas. M. Manly, Curtiss Aeroplane Co.; and J. A. Mathews, Halcomb Steel Co., all members of the committee. K. W. Zimmerschied is also a member, but was not able to be present.

This committee has no direct connection with the Society or with its standardization activities. On account of the nature of its work, however, the Standards Committee of the Society will extend all possible cooperation in order to obtain the best results for the Government. The committee will, of course, be in close touch with the Aeronautic Division of the Standards Committee in regard to a number of questions.

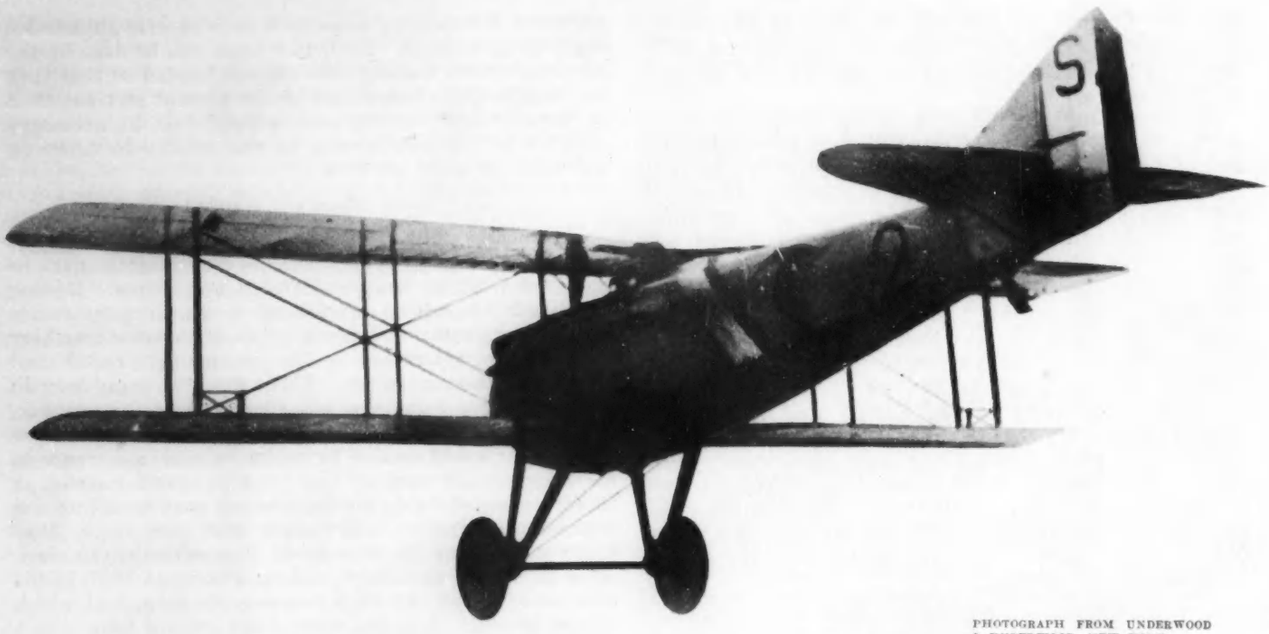
It is planned to cooperate with the best engineering ability both of this country and of the Allies. The work of inspecting and testing materials for the Allies will probably form part of the committee's duties.

There was considerable discussion at the meeting as to the proper inspection policies for the Government to follow. It was said that there seems to be a growing tendency abroad toward Government inspection of the final products rather than progressive inspection. The inspection of progress work involves duplication of work and slowing up of production.

It was voted that the rules of procedure of the American Society for Testing Materials should be followed in the inspection of materials.

The suggestion was made that the inspection work should be divided between two general groups; one for ferrous and the other for non-ferrous metals. Such groups could formulate methods of testing the physical properties desired and of inspection at the mills.

A sub-committee on steel was appointed to investigate both the American and foreign aeronautic steels and will formulate a recommendation for such materials.



PHOTOGRAPH FROM UNDERWOOD & UNDERWOOD, NEW YORK

Captain Guynemer of the French Flying Corps in Flight

Design *and* Production of Aircraft in Time of War

By WING COMMANDER J. W. SEDDON*
(*Non-Member*)

Paper at SEMI-ANNUAL MEETING *Illustrated with* PHOTOGRAPH

FROM what I have so far read and heard, I have gathered, perhaps quite wrongly—indeed, I sincerely hope so—that manufacturers here are far more anxious to reproduce standard types of aircraft, than to enter the field as designers and builders of original types of aircraft.

However that may be at the moment, I am perfectly certain that very shortly after a firm has learned to turn out a good standard article, it will be attacked by the most exhilarating of all microbes, to-wit, the microbe which makes men design aircraft that shall go one better than anyone else's.

For the moment then I want to deal with the design of military aircraft in wartime.

We may well start out with one of the proved facts of aerial warfare: "The command of the air rests very largely indeed with that side that produces the best single-seater fighter." Provided, of course, that it is produced and used in sufficient quantity.

This state of affairs is so clearly recognized in France and Great Britain that particular attention is devoted to the improvement of this type, with the result that new and improved designs are now being built and tested as fast as possible. This results, of course, in many new designs being produced, of which, however, only a few show outstanding merit and are consequently reproduced in quantity. Of the designs hitherto popular some have survived a year, some six months, and some have had a life of usefulness on the Western Front of only three months.

The designs that have lasted a year have always finally overstayed their welcome, and I think that probably we shall find a "vogue-period" for the single-seater fighter type to be never more than six months in the future.

The real reason of this is, of course, that it takes the enemy not more than six months in which to get to know all about any particular type and copy or improve it, if he has not already something better of his own. Then something better has to be forthcoming or command of the air will have to be conceded.

The same line of progress certainly applies to other types of airplanes than the single-seater fighter, as also to various types of seaplanes, but to a far less extent.

IMPROVING THE FIGHTING AIRPLANE

It is clear then that the designer, particularly the designer of the small fighting airplane, whether he be in France, Great Britain or America, is always confronted

*Royal (English) Naval Air Service.

with the problem of designing a type that is an advance on any temporary machine of a similar type. A machine can be an advance on a similar type in one of two main respects:

(a) Because it possesses a better performance.

(b) Because its fighting facilities are better.

Each of these main headings includes a number of subdivisions; thus better performance may mean better climbing only, better speed only, greater endurance, or any combination of these, while better fighting facilities may mean an improvement in maneuvering ability, view, positions for guns, weapons, or in any combination of these.

The designer then who sets out to design a new type must proceed along one or more of the following general lines:

(a) Increase the horsepower-weight ratio.

(b) Decrease the wing or structure resistances.

(c) Devise a new arrangement of the supporting planes, with regard to the position of pilot or crew.

Horsepower-Weight Ratio.—This is most readily increased by the utilization of greater horsepower or of engines lighter per horsepower. It is most readily achieved in this way because progress in aviation engines is still fairly rapid. But a good deal can be done by close and accurate design, which implies the removal of all redundant weight.

Wing Resistance.—The decrease of this resistance is a matter for the wind-tunnel experimentalist and not for the designer, but the converse has actually been true in a great measure in the past.

Structure Resistance.—The designer and the wind-tunnel experimentalist must work closely together in decreasing this resistance; it involves in any case the reduction of exposure of engine parts, external fittings and controls, besides the accurate shaping of the body and the simplification of the chassis, which are matters entirely for the designer.

Arrangement of Supporting Surfaces.—It is possible to vary the arrangement of the planes in an infinite number of ways, but the prime object in view is practically always to improve the view of the pilot, and roughly therefore the favored types are the parasol monoplane, the biplane with planes of unequal chord and the heavily staggered triplane. It is probably true that the practically unstaggered equal-planed biplane with a gap equal to the chord and an aspect ratio, in accordance with the gross weight, running from about five in very small machines to perhaps ten in the very large ones, gives about the most efficient aeronautical arrangement for an airplane.

Any deviation from such an arrangement may and usually does involve greater efficiency of the supporting surfaces, but at a cost of greater weight. It is possible to make these two factors balance and perhaps even show an over-all aeronautical advantage for the unusual arrangement, but a designer has to be most intimately acquainted with every branch of aeronautics before he can attempt such arrangements with any real chance of making good against the simpler structure.

METHODS OF DECREASING WING RESISTANCE

I now want to return to the subject of the reduction of wing and structure resistances, because it is in these two respects quite as much as in the matter of engine design that notable progress has recently been made by designers in France and Great Britain.

There are two ways (of these the first is by far the most important) by which wing resistance has been notably reduced, namely:

(a) The employment of low resistance aerofoils.

(b) Properly shaping the wing tips.

To grasp thoroughly the aerofoil resistance problem it is necessary to preface that wind-tunnel research (following indeed in the wake of practical experiment) has now given us a very good range of aerofoils, varying from the low-lift aerofoil, which carries about 5 lb. per sq. ft. at 45 m.p.h. at its maximum lift angle, through the medium-lift aerofoil carrying about 6 lb. per sq. ft. under the same conditions, to the high-lift aerofoil which carries 7½ lb. per sq. ft. under the same conditions.

It is obvious that when the minimum speed is specified, if the aerofoil carrying 7½ lb. per sq. ft. is utilized in place of that carrying only 5 lb. per sq. ft. (both at 45 m.p.h., the speed usually named) there will be a very large saving in area and consequently in weight by using the high-lift variety. The weight saved is not by any means confined to the saving of supporting surface, because first the stresses are reduced, then the tail area or length of body may be reduced. In fact, as a rough approximation it can be assumed that the saving is at the rate of 1½ lb. per sq. ft. of area saved. This at once

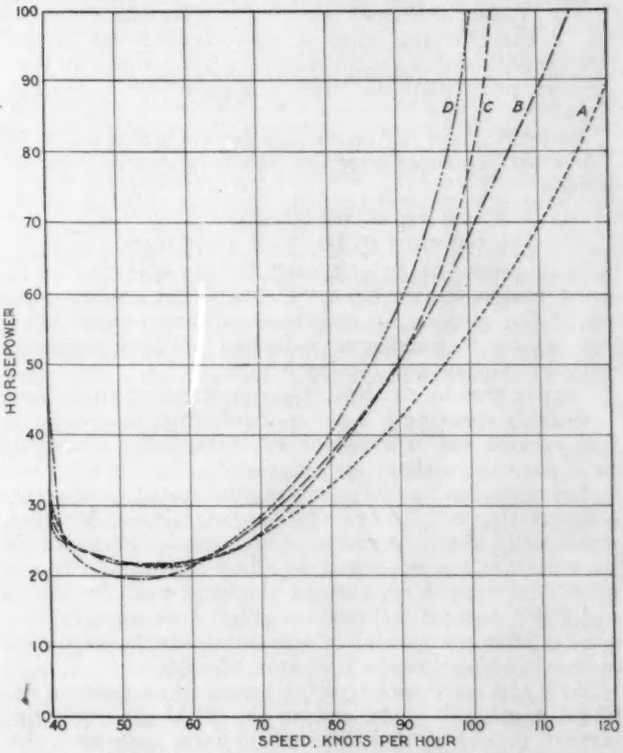


FIG. 1—HORSEPOWER CURVES FOR VARIOUS TYPES OF AEROFOILS

	Type of Aerofoil	Weight	Area	Weight, Lb. per Sq. In.
A	Modern Scout	2,000	357	5.6
B	Old Scout	1,962	331	5.9
C	Medium Lift	1,889	283	6.7
D	Moderately High Lift	1,848	256	7.2

Compared on the basis of the same useful load and minimum speed of 40 knots. Biplane, aspect ratio of 6, gap = chord and no stagger used.

very materially increases the horsepower-weight ratio in favor of the high-lift winged machine.

Moreover, with the reduction in area and weight there come improved view and ease of handling—except that in dives the high-lift wing type will have a comparatively low limiting speed. All these factors, therefore, appear to give the high-lift wing a very big advantage over the

low-lift type, but actually the advantage is altogether on the side of the low-lift wing. This is because at fine angles the head resistance of high-lift aerofoils is very much greater than that of the low-lift types, so much greater, in fact, that the greater area and weight necessitated by employing the low-lift aerofoil actually requires less horsepower at high speed.

For example, if 30 hp. net is available for the wing resistance then there is little to chose among any of the wings referred to in Fig. 1, but when 45 hp. becomes available for wings alone then the speed range of the low-lift wing becomes from 40 to 92 knots as against 40 to 80 knots for the wing with the greatest lift. A horsepower of 45 for wing resistance is equivalent to about 120 hp. engine, or, roughly, one horsepower per sixteen pounds. The diagram shows that as the horsepower is increased beyond this amount the advantage in favor of the low-lift wing increases still more markedly.

It is quite possible that the super-scout of the near future with a low-lift type of aerofoil will have a speed range of 50 to 150 m.p.h. The same machine fitted with a medium-lift type will probably achieve 50 to 125 m.p.h. and with the highest lift aerofoil 50 to 100 m.p.h. only.

Fig. 1 also illustrates what little difference there will be in the climbing rates of any aerofoil, for, despite the weight handicap against the low-lift aerofoil all types require practically the same minimum horsepower for flight.

Returning now to the smaller factors which go to improve performance, there are two points to be carefully noted:

(a) The shaping of wing tips.
(b) The reduction of structure resistances.

With regard to (a), it must be admitted that not a great deal is known beyond the fact that any rounding off of the corners, of an otherwise square-ended wing-tip, results in considered reduction of head resistance without causing any loss of lift.

This is true up to about 4 per cent reduction in area.

Roughly speaking a 4 per cent reduction in area properly carried out will reduce the total wing resistance by 4 per cent without any appreciable loss in lift.

Not much can be said regarding the reduction of structure resistance. The careful designer must, however, strive after the most stream-line form for every single item outside his main and auxiliary surfaces. Thus a great deal depends on keeping the body small in section and finely tapered aft and as pointed as possible forward. Stream-line wire is now being employed abroad in war machines to the exclusion of cable.

More and more care is being bestowed on external fittings, struts, tail skids, and so on. It is extremely important to add as few exterior objects, such as bomb gears, bomb sights, compass, guns, wind speed indicators, oil, water or gasoline tanks, as possible. Obviously not all these parts can be entirely located inside the machine, but considerable studies are being made in order to obtain that end.

AUTHOR'S CONCLUSION

To conclude, I urge that inasmuch as two heads are better than one, so three are better than two; consequently it is most desirable that the designers in this country be encouraged to compete in the race of producing the best fighting scout.

The field is perfectly open and the judging is above suspicion because the ultimate judgment is recognized to be in the hands of the pilots, who demand to be supplied with the best and only the best.

THE DISCUSSION

F. C. MOCK:—What is the range of horsepower used in the scouts?

COM. J. W. SEDDON:—The Hispano engine in the Spad airplane gives 150 hp., and I think they are about to have a 200-hp. Hispano. The same thing applies to the British scout SE 5. But the majority of scout machines have rotary engines of only 130 hp. at the present day. This will be increased in the near future so that they will be 150 to 160 hp.

CHAIRMAN MANLY:—Those have revolving cylinders?

COM. J. W. SEDDON:—Yes. So that we can practically say there are two types of fighting machines: one having the fixed-type engine of 200 hp., and one with the rotary engine of 130 hp., which will be 150 hp. very shortly.

R. N. MACALISTER:—What proportion of airplanes in use carry starting equipment?

COM. J. W. SEDDON:—No airplanes, so far as I know, have any starters, but all types of seaplanes have them.

CORNELIUS T. MYERS:—What types of engines have given the best endurance and efficiency in the field?

COM. J. W. SEDDON:—That is a big question, but dealing again first of all with the fighting machines the answer is at the present moment the Hispano-Suiza and the Clerget engine. In the larger machines in England, such as the large bombing airplanes, the best engine we have, the one we use the most, is the Rolls-Royce, of about 250 hp. But one cannot actually lay that down, because the efficiency in engines changes, just as it does in the scout business. One scout, such as the Morane, comes along and it falls out and then the Nieuport comes; the Nieuport goes out and the Spad comes along. It will not remain in long before probably the Nieuport comes back again. We had the Gnome and then the Le Rhone and now the Clerget engines. It is rather unfair to tie it down, but I will tie it to these three, namely, the Clerget, the Hispano, and the Rolls-Royce, which just at the moment are the three engines.

F. C. MOCK.—I understand that the aerofoil of the planes is usually taken as being that of the rib. In the lateral spacing between the ribs the cloth always deflects a little, so that the actual thickness is less. To what extent does that affect the efficiency of the plane? Would it be worth while to eliminate that deflection and to maintain the regular section of the plane?

COM. J. W. SEDDON:—That was tested carefully in the wind tunnel on an aerofoil that was one of the best at the time. The tests showed that there was a marked falling off in the lift, but when it was retested with the sags filled in, the loss of lift still persisted. Thus it was found that the original test of that aerofoil was all at fault, and that practically the little sags in the canvas did not affect the lift at all.

CORNELIUS T. MYERS:—We have made up our minds to bring the greatest assistance that is in our power, not only as a duty but because our sympathies are with the cause. Besides being automobile engineers, which was perhaps the foundation of our membership here, we have linked arms with the tractor engineers, and we will do our best to see that those brave men and those brave women over there are fed; we have linked arms with the men who are making the motor-boats and will chase the submarines off the earth if it is possible to do it; and we have got both arms around the airplane work and we are going to sweep the Germans out of the sky if we have to fly our machines across the water to do it.

Classes and Uses of Battleplanes

By CAPTAIN AMAURY DE LA GRANGE

French Flying Corps

THREE different types of machines are used in modern warfare,—the fighting, the reconnaissance and the bombing machines. All of these except the fighting machines must be able to carry out light bombing, that is to say, they must be able to transport 200 lb. of bombs. When we say bombing machine, we mean a machine which is designed only for bombing purposes. This must have a carrying capacity of about two tons.

A fighting machine must have the following qualities: speed, handiness, great climbing ability and the ability to travel at high altitudes. The constructor must bear this in mind, and never sacrifice one of these qualities for the benefit of one of the others. If a machine was so built that it would be excellent for fighting at low altitudes, but that it would be no good above 12,000 ft., it could not be adopted by the army, because the conditions of modern warfare are such that the machines are constantly obliged to seek higher altitudes. It is not rare nowadays to meet German airplanes at a height above 18,000 ft. When it comes to fighting, the quality the pilot most prizes in his machine is handiness, of which speed is one factor. Therefore, we cannot value exactly the worth of a machine before it has been tested thoroughly by old and experienced pilots.

Qualities of Reconnaissance Machines

The reconnaissance machines ought to have the same qualities as the fighting machines, but naturally they cannot have them to the same degree, because they have to carry more weight, and therefore are bulkier. They must carry an observer, extra fuel, a wireless apparatus and occasionally bombs. The landing speed of these planes is a factor that must be taken into consideration for two reasons: the first is that as the best pilots will be used to fly the fast fighters, those that are left to fly the reconnaissance machines are often less skillful. The second reason is that night flying is becoming more and more necessary. The danger of landing at night must not however be exaggerated. It is merely a question of training.

The number of reconnaissance machines needed by an army depends upon its numerical strength. It has proved useful to have four reconnaissance squadrons of fifteen machines each, for every army corps of two divisions. But the number of both fighting and bombing machines is limited only by the possibilities of production, and by that of training a sufficient number of pilots. From a military point of view, the reconnaissance machines are the most useful. However, these cannot carry out their work without the help of the fighting machines. The bombing machines are much less useful unless they operate in very large numbers, and in a sky in which there are no enemy machines.

It must not be forgotten that speed and climbing ability will often be as good weapons as a machine gun. There is a saying in the cavalry that runs as follows: "The horse is the best weapon of a cavalryman." The aviator can say the same of his machine, therefore the pilot must have confidence in it, and the constructor must give it a high factor of safety. As a rule, there is actually no danger in flying because of defects in the machine. The great danger comes from the high speed at which one must fly, which makes the slightest mistake of a pilot, when he is near the ground, a mortal one.

All modern airplanes are of the tractor type. The reason is that, in theory, each airplane should defend itself. The pusher type, if attacked from the rear, could not defend itself.

Tests of New Engines

Before an engine of a new model is accepted by the French army, it undergoes a test of fifty hours. During five days it runs twice a day for five hours, during a half-hour of this time at full power, and for four hours and a half, at nine-tenths of that power. For example, an engine which is said to produce 200 hp. will be tested during five days, twice a day for five hours, and will run for the first half hour each time at 200 hp., and for the following four and one-half hours at 180 hp., this last to compensate for the fact that an engine loses one-tenth of its power at 6000 ft., because of the lowered compression in the cylinders.

When a new engine is finished it is tested for three hours on a testing block, then taken apart, examined, reassembled and tested for twenty minutes.

The airplane when complete is accepted only after having been tested, and having fulfilled all the conditions required in the contract. The climbing speed is one of the most important factors.

Difficulties of Production

The plane itself can be easily built; this cannot be said of the engine. The airplane engine is very different from that of the automobile. The constructor is limited by the weight, and has to solve the difficult problem of designing an engine weighing only about 2 lb. per hp., and which will be reliable and not cumbersome.

The automobile does not work constantly at its maximum power as the airplane does. Fortunately, at high altitudes the engine, as it gives less power, is under less strain. It would be interesting to test the engines artificially, under different air pressures, thus reproducing the conditions under which they will be used.

The constructors will have to use remarkably good material. The steel must have high resisting force, and yet not be brittle.

The crankshaft and the roller bearings must be of as light weight as possible to avoid vibration and to allow the engine to turn at a high number of revolutions.

Aluminum pistons have given very good results, because they are of lighter weight, are excellent heat conductors and therefore preignition is less likely. When alloyed with other metals, aluminum can be used for many parts of the engine.

Hardening is very important. It must penetrate progressively into the metal it is covering.

Lately, most of the cylinders have been made of steel,

but it is possible that cast iron may again come into use if we must build engines turning at 2000 or even at 2500 r.p.m. The steel cylinders will not allow this, and although their weight is less, the increased weight of the cast iron will be more than made up by the greater power of the engine.

Engine Construction

Examining the different types of engines, we find that actually the qualities of rotary engines are balanced by those of the fixed-type engines. Each has its advantages, but it is probable that the fixed-type engine will soon be the only one that will be satisfactory. The weight of the fixed type, which was its great drawback, has been greatly lessened lately. It will probably be even more so in the future. Its horsepower can grow without its size increasing as much as that of the rotary engine. It does not seem possible to build a rotary engine that can turn faster than those in existence do, therefore, in order to increase its horsepower, the size of the cylinders would have to be increased so greatly that the engine would be impracticable. On the contrary, the fixed engine will certainly be brought up to 2000 or 2500 revolutions.

Aviators and Mechanics

It is almost impossible to say beforehand if a man can become a good aviator. Some of the very best French pilots were in such bad physical condition that they had been rejected by the army. In spite of this, as it is necessary to train a great number of pilots in the shortest possible time, men in the best physical condition must be chosen. If after a short period of training they prove slow at learning, though not absolutely unfit, they must be rejected without hesitation. No time must be wasted over slow pupils.

An aviator must always do individual work, consequently, he must have a great sense of duty. He must also be more intelligent and better educated than the average infantryman. This does not mean that all the pilots must necessarily be officers. In the French army many pilots possessing these qualities are either private soldiers or non-commissioned officers. The more mechanical and engineering knowledge the pilots possess the better it is. This they must be given during their training, so that when they are at the front they will be able to oversee the work of the mechanics and to test their engines themselves.

A good pilot is always busy with his machine when he is not flying. He must also be a good shot and practice daily. The importance of this is understood when we know that Guynemer, the "star" French pilot (who has brought down 43 German machines) is now so skillful that he often brings down the machine he is attacking with a single shot.

The life of the pilot lies often in the hands of his mechanic. The latter must be competent and careful. Each pilot in a French squadron has two mechanics to take care of his machine; one of them is an expert and does all the fine mechanical work while the other cleans the engine, oils it and fills the tanks. The mechanics, as they always work for the same pilot, are proud of him and take the greatest care to keep his machine always in good order.

It is impossible to train a good mechanic rapidly, and therefore, they must be chosen among the workmen who have a thorough knowledge of automobile engines. No important repairs are made at the squadron, so it is not necessary to have good adjusters there. The place for these is in the repair shops to which the engines are sent when important repairs are to be made.

I hope these scattered remarks will show what a powerful aid in aviation the United States can be to the Allies. The Americans will make good pilots; their mechanics can be used at the front or in factories. This country is so great industrially, that if the program which the American authorities have outlined is carried through, it ought to be one of the main factors in determining the strength of Allied Aviation, which depends so largely on industrial excellence.

THE DISCUSSION

CAPT. AMAURY DE LA GRANGE:—Our machines have always been, and are still, more handy than the German ones. This is one of the reasons why our fighters have been so successful. A man like Guynemer, for instance, who is considered in France the very best of our best pilots, is now so extraordinarily skillful that he will attack a German machine very often without having been seen by its pilot. He will manage to hide behind the wings of the enemy machine; that is to say, he will know how the enemy-machine is built, what is the angle at which the enemy-pilot cannot see on account of the special structure of it, and he will manage to approach the enemy-machine in such a way that he will not be seen, and when he will be seen it will be too late. In order to carry this out his machine must be extremely handy and must obey like a well-bred horse.

About a fortnight ago Guynemer, who at the time had brought down 39 machines, left the front in a machine he had to test out. He flew above the lines testing his machine, as well as hunting for Germans, when suddenly he saw a German machine. Of course nothing could stop Guynemer from attacking a German machine when he saw it. Well, this country will have a good many fellows of that kind after a few months in France. Down he went and brought down the German machine at one shot; he made the next loop, found a second machine and brought it down with a second shot, and all within a minute. Then he thought, "This is good work and I am going home," so he did. He called his mechanic to fill up his tank, and off he went to make another test of his machine. This is absolutely true; it actually happened. He brought another German machine down and started home thinking that three was a very nice bag. His comrades were waiting for him; it was five or six o'clock in the afternoon, and nearly dark. All the squadron—because he is a god to them—were assembled to see him come home after bringing down his three Germans, when suddenly, by looking upward, they saw a German machine coming to take a photograph of the aviation ground. Their machines were all in and they could not haul up and get out; it was useless. But over there was a little black spot, which was Guynemer. He saw the German over the field and naturally went after him and brought him down right away.

I am asked to tell the age of Guynemer. I am afraid of making a mistake, because I do not know exactly, but he is either twenty-one or twenty-two.

About eight or ten months ago night flying, while not absolutely unknown, was not frequent in our army. The reason why we are now asked to fly at night often is this: the Germans will not allow any columns of infantry or artillery to be on the roads in the daytime; they will make nearly all their movements at night. If they want to concentrate say five or six army corps, which is a very large body of men, and artillery on a certain sector to prepare for an attack the transportation will all take

place at night. Our staff must know this and it is through the aviators that our staff will learn it. The result of it is that we must fly at night; we must see how many trains go through a certain station during a certain time. We know that the average, for instance, is ten during the night. If we see that steadily for a few nights this number is fifty, we know there is something going on, and the French Staff will probably bring behind the French lines more artillery and more infantry to meet that attack.

Of course night flying is dangerous, because emergency landing at night means certain death. But as long as the machine keeps flying and in good condition—and now they are very reliable—one can land easily at night on a narrow territory if it is properly lighted. We formerly used for landing simply gasoline fires, put gasoline in big vats and lighted them. Three of those big flares, in a triangle, showed the direction of the wind; and the machine landed between the two fires and in the direction of the third. Now we have in each squadron a big searchlight, which is directed on the ground. The machine lands with the searchlight at its back, right in the flare, and the pilot sees the ground perfectly.

Our actual method of flying in the air, that is, the tactics that we use, the orders we give our squadron commanders, are all based on the number of machines we have. Knowing that we have, for instance, in a certain sector ten fighting squadrons, we will use them in a certain way. Those tactics will be absolutely different, and certainly far more efficient, if instead of ten squadrons we had in the same sector one hundred squadrons; and even more so if, going to evidently absurd figures—because there is a limit to everything—if we had a thousand squadrons.

I believe—and I have had a certain experience in it—that bombing done by a few machines, each of them carrying a small number of bombs, even if the men in them are lucky enough to hit the target, will not be efficient. It is really of little military value. But I will say exactly the contrary if we can have a large fleet of extremely powerful bombing machines, which will carry an enormous weight of bombs; the numbers of which can be counted by hundreds instead of by units.

What America Must Do

I believe that the program here in America, if this country wants to do anything very efficient as far as aviation is concerned, must be this: Build an extremely powerful fleet of fighters, send them to Europe with the pilots trained here and clear the sky of every enemy. In the meantime, having built a powerful fleet of bombing machines, send them over there and then go for the targets. There will be no more enemy machines flying, and if they try to fly they will be brought down. So that the big fleet that will go bombing whatever manufactory or whatever railway station is chosen, will go there in perfect safety.

There seems to be a feeling in this country that everything in aviation is changing, perhaps not from one day to the other, but certainly from one year to the other and from one month to the other. Therefore we do not know what we must start on. I think this is absolutely wrong. We know that the engine we are building now will not perhaps be the engine that will win the war, if it shall run another year or two or three years; but we must start on something. Experience has proved that a new machine and a new engine have always been used on the front for at least one year after they have been produced in large numbers. Supposing today a new type of engine or plane was found the speed of which would be much higher than that of the fighting machines now in use on the front; it would take a long time before every fighter on the front could fly at that speed. During that time we must have something, and although we know the machine available is not the best, it may be a good one to bring down the Germans.

Now I think what should be done in this country is to start building whatever type of machine is considered best. Take the English or the French type, the very best our fighters are using over there, take the best bombing machine or the best reconnaissance machine, and go ahead and build them. Meanwhile, if we find something that is better, all right; the industries in this country would be accustomed to building aviation planes and engines. It would not be a new proposition to them. They will have their jigs and fixtures ready and their workmen will be ready to work, and will have solved many of the problems that they had not known before, and will go ahead much more quickly. The man who has been telling us that it is not worth while spending dollars on something that will not be very good next year is, I think, mistaken. We must do it, and it is the way to learn.

A MEMBER:—What is the principal difficulty resulting from the use of steel cylinders?

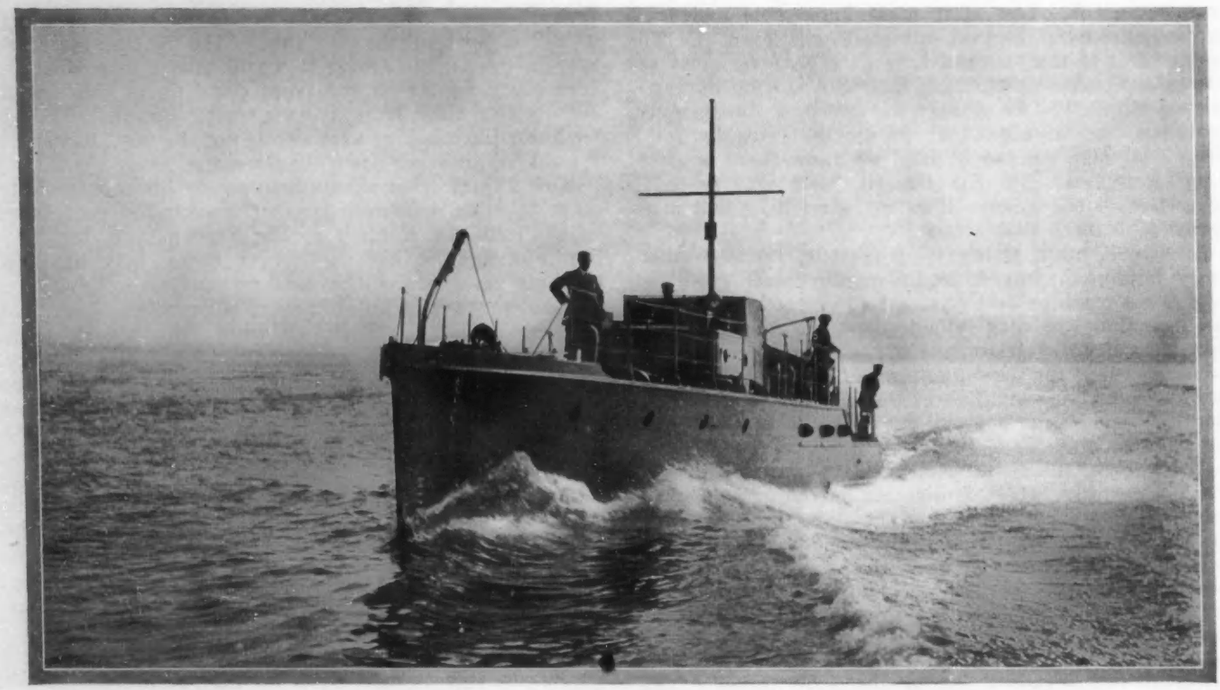
CAPT. AMAURY DE LA GRANGE:—The steel cylinder is all right as long as the engine does not turn at more than 1800 r.p.m. But if we find out later that the engine can give much more power if it turns at 2500 r.p.m., and the other parts of the engine will allow it to turn at that speed, we will have to take the cast-iron cylinder, because a steel cylinder will not allow such high speed.

NEIL MACCOULL:—What is the most frequent source of trouble with the European engines?

CAPT. AMAURY DE LA GRANGE:—The most frequent source of trouble with the engine is the German machine against which we are fighting. In the water-cooled engine, which I think is the engine we will use more and more, the great trouble has been the water cooling when flying at great altitudes. At 6000 ft. the temperature is not very low in our country, but at 17,000 or 18,000 ft., where we often go with fighting machines, it is extremely cold. Therefore, naturally the cooling of the engine will be excellent, will even be too good; so that if it is necessary to attack a machine at a lower altitude by cutting off the engine and diving, the cooling will be so great that when the engine is started again, and all of its power is needed, it will not develop the full power. On some types shutters are used to prevent the air from passing through the radiator when starting. I think it is practically the only difficulty we have. We have engine troubles, of course, that are bound to happen. But the engines we use are all of them very reliable. In the squadron I was in, out of the ten machines only three were broken in a year on emergency landings coming from engine failures. We nearly always come home, even if one or two cylinders are not working.

NEIL MACCOULL:—Is much trouble experienced with the exhaust valves on the engine when they are run at high speeds, such as they are when driving the average geared-down propellers?

CAPT. AMAURY DE LA GRANGE:—At the Lorraine de Dietrich factory in France they are building engines that have two exhaust valves. There would be no difficulty in that if it was perfect in proportion. Anyway we have never had any trouble in what we call an engine that breathes well; that is, with large exhaust and inlet valves.



"Elco" Submarine Chaser Being Tested by the British Admiralty

Building Submarine Chasers By Standardized Methods

By HENRY R. SUTPHEN* (*Member of the Society*) *Illustrated with* PHOTOGRAPHS

IT was in February, 1915, that we had our initial negotiations with the British naval authorities. A well-known English shipbuilder and ordnance expert was in this country, presumably on secret business for the Admiralty, and I met him one afternoon at his hotel. Naturally the menace of the German submarine warfare came into the discussion; we both agreed that the danger was a real one, and that steps should be taken to meet it.

I suggested the use of a number of small, speedy gasoline power-boats for attacking and destroying submarines. My idea was to have a mosquito fleet big enough to patrol thoroughly the coastal waters of Great Britain, each boat carrying a 13-lb. rapid-fire gun.

As I looked at it, there was just one answer to the problem, and that was complete standardization. Fortunately, I had had some previous experience along that line, which had been very valuable, and the idea naturally presented itself that a duplication could be extended to war vessels.

On April 9, 1915, the contract for fifty "chasers" was signed, and we went to work so diligently that by the first of May the master or pattern boat was in the frame at our Bayonne yard. It seemed to us like a big undertaking, but the real business had not even started.

After the sinking of the Lusitania we received a cable ordering 500 additional "Sutphens," our code word for the submarine "chasers"; we were asked to build 550 of these boats and deliver them in complete running order by Nov. 15, 1916. Taking out Sundays, this gave us an actual working schedule of 488 days. This meant pretty close figuring, but I was sure we could manage it.

Scientific Standardization

Once again I must reiterate that the touchstone of our success was scientific standardization. Our chief designer, Irwin Chase, was quick to recognize this essential, and his keen foresight and far-reaching judgment were all important factors in the practical realization of our ideas. For this new task involved duplication on a hitherto unheard of scale in boat building and every mistake would have been magnified five hundred and fifty times; this meant that we could not afford to make even a single

*Vice-president, The Elco Company.

error in plan or practice. For instance, there was the question of material; where could it be found in sufficient quantity and of proper quality? White oak enters extensively into ship construction and the supply in this general locality is just about exhausted. Finally we found it in West Virginia and the contracts were let without delay. Yellow pine also was needed, and there was but a limited supply in the local markets. Fortunately the mills in the South were anxious for work, the war having destroyed most of their export trade, and they were glad to take our orders and to guarantee prompt delivery of the highest grade, long, straight stock, absolutely free from knots and hearts, the finest lot of selected lumber that has ever come out of the Southern woods. Just to show what thought had to be given to every detail, it was specified that the longest plank must not exceed 42 ft. The reason was that the lumber had to be shipped in end-door boxcars, and the longest in general use was only 43 ft.

Obtaining Supplies

Another consideration was where to get the castings for the metal work. The foundries that ordinarily handled our orders could not possibly turn out the quantity now called for; it became necessary then to hunt up other plants not hitherto engaged in shipbuilding work, and enlist their cooperation. And this we did; for example, the Tiffany Studios took the contract for casting the bronze struts, quadrants, and rudders. Before this, the Tiffany Company had turned out only work of the ornamental and artistic kind; but it knew how to make bronze castings, and was glad to get the order for a duplication job of this magnitude.

Our plans were made so carefully and checked so thoroughly that once the work started it moved along with the utmost smoothness and precision. As Mr. Chase used to remark to me: "We are making every hurdle and batting 1000 per cent." And this was true, thanks to Mr. Chase himself and to my other associates. The whole success of the enterprise was dependent upon their brains and loyalty, and I am proud indeed to say that no one in our whole employ failed to do his utmost duty; small wonder then that we succeeded in our task.

The fabrication work was done at Bayonne, and the material was shipped into Canada, where it was assembled at two yards which we established in Montreal and Quebec on the St. Lawrence River.

Each of the boats was 80 ft. in length, 12½ ft. beam and 4½ ft. draft, their shallow draft making them immune from torpedo attack. They were equipped with two 220-hp. six-cylinder, air-starting, reversing gasoline engines, giving a speed of 19 knots under full load, with gasoline-tank capacity of 2400 gal., giving a radius of 1000 to 1200 nautical miles at moderate speed.

THE DISCUSSION

HENRY R. SUTPHEN:—The building of submarine chasers by standardized methods was due to the discovery of hidden resources in boatbuilding. The job we had was to handle 275,000 horsepower in internal combustion engines for 550 boats, that would have stretched out in one line eight miles, with a guaranteed speed of 19 knots or no sale, good sea-keeping qualities, good gun platforms and living quarters for ten men and a radius of action giving 1000 knots with a speed of 15 knots an hour and one of 750 knots at full speed.

That type of boat did not exist before we offered it to the British Admiralty in the early part of 1915. The submarine menace was not at its height at that time, but being in the business of building submarines, we realized that sooner or later it would be a very grave question to the Allies. It was necessary to determine how large a boat could be built, what speed could be attained and whether it could keep the sea. We had progressed further in this country in the building of motorboats than they had abroad, owing to our wonderful water-ways, and I think, too, we had carried the ocean racing to a further extent than any other country had. Boats had been sent abroad under their own power, driven by gas engines. The Bermuda race, which was considered a dangerous event at the time it was first projected, had been run for a number of years without loss and all that gave us a line on what a small boat would do at sea if properly manned and powered.

We first offered to build fifty boats in a period of twelve months. As the boat-building industry is comparatively small, this was an unheard of number of boats of that size. Ordinarily half a dozen boats of that size might be built in a year in the whole country. We had to take a chance in the matter and the customer was willing to gamble with us to a certain extent, although he did want that guarantee of speed or no sale, which was a tough proposition.

The design was soon perfected and a master boat built; then we started in to work on the basis of scientific standardization, which has never before been carried to such an extent in boat-building. Owing to the neutrality of this country we could not assemble and deliver the complete boat in American waters. That seemed a tremendous hurdle to jump, but of course we realized it when we made our offer for the delivery of the boats. We were not then at war and we did not want to embarrass our government.

To jump that hurdle we assembled the complete boat in Canada. Fabricating the material in our main works at Bayonne, we shipped every part of the hull, every detail of fastening, equipment and engine, into Canada, establishing two plants, one at Montreal and one at Levis, opposite Quebec. We had to employ, in order to accomplish the work within the time given us, 12,000 men, of whom probably not 10,000 had ever been employed before in boat-building. In our Canadian plants not 5 per cent of the men who were employed could speak a word of English.

Yet by the aid of a few leading men sent from our main works, and by their patient and careful instruction in how to do each particular piece of work, these men were instructed in the assembling of the completed boat and became so expert and proficient that our piecework rate, which was established soon after the first few boats had been built, was so liberal that they had never before earned the amount of money that they did in the building of these boats. They were therefore extremely well satisfied with the job.

Very little overtime was spent in completing the work. Yet again, when the men were called upon to meet certain conditions of deliveries they willingly did it without calling for overtime pay.

Why Slow-Speed Engine Was Selected

The powerplant consisted of two six-cylinder, 10 by 11-in. reversing Standard gasoline engines, turning to develop their full power at 460 r.p.m. In deciding upon that powerplant we did a wise thing at the beginning; because there was a difference of opinion as to the type of engine with which these boats should be equipped. The high-speed engine, developing large power with light weight, was most attractive from a manufacturing standpoint; but from the point of propulsive efficiency we

knew that the slow-turning engine would prove the best, particularly at sea, where heavy weather would be experienced at times and the maximum power required.

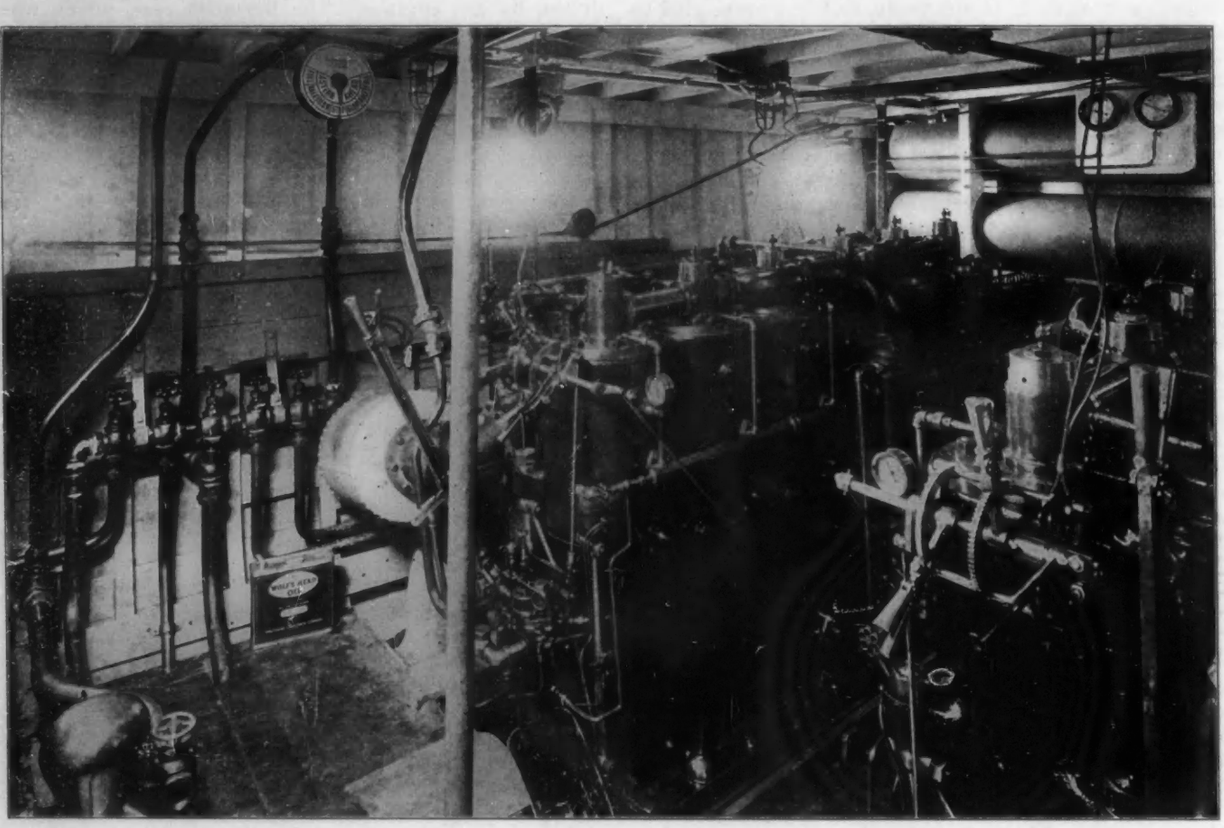
The engines were manufactured—never before had the opportunity been offered to manufacture marine engines in such quantity—in three plants: the Standard plant at Jersey City, our plant at New London and the Indianapolis plant of the Lyons-Atlas Company. They were thoroughly tested on the block and further tested when they were put in the boats. In handling 275,000 horsepower we never had a broken crankshaft, a broken connecting-rod, a cracked cylinder or any difficulty that was of any consequence.

I remember one engine in which the inspectors thought the main bearings were running too hot. We did not agree, but to satisfy them we took the whole engine out, sent it back to the factory, and rescraped the bearings. It was much better to do that than to attempt to do it at the assembling plant, where we had no facilities at all.

Each boat was tested in the water and had to attain the required speed in a light condition. Every twenty-fifth boat was tested officially under load conditions, and with an equipment equal in weight to the full armament and gasoline. The gasoline tanks carried in the boats had a capacity for 2400 gallons, which was in itself a tremendous weight.

The question of the handling of the boats by our customers was one that concerned us considerably. The British Admiralty thoroughly trained the mechanicians and the men who commanded the boats on deck. Each man spent four weeks in the training ship, where a pair of engines was set up. One was put in operation with its propeller in a tank, the other was taken down and put together by the class; after four weeks the men graduated were thoroughly acquainted with the details of the engine and could handle it perfectly.

Every one of the boats arrived on the other side and is now in service, giving a good account of itself. We have had our men abroad to find out how the customers used the boats and if they were well pleased. The most favorable reports have been given by the people operating them and by the officers of the Admiralty in charge of their maintenance. Very few breakdowns have occurred, although the boats have been given very hard service and have been doing work never expected of them. It is not uncommon for them to operate in groups of six or eight at a time two hundred miles off shore.



Interior of Engine Room of Submarine Chaser, Showing the Two 220-Hp. Engines

It is very gratifying to have the customer appreciate what we have done by giving us within the last week an order for the same type of boat that we built two years ago. The question now is, as a result of this experience how far can we carry the standardization of boat-building? This question is uppermost in the minds of most of our people at this time. I believe that it is feasible to carry the standardization of steel shipbuilding, if a quantity is desired of one type of vessel, to an extent that has never been dreamed of; I can see the possibilities of this occurring shortly, and it will surprise the world. But it can only be done by standardized methods.

A MEMBER:—What is the fuel consumption of those boats?

HENRY R. SUTPHEN:—The shop test calls for 0.9 of

a pint per horsepower per hour, and in actual practice we obtained that. We had to guarantee the radius against a penalty, and on the final trial the fuel and the number of knots covered were carefully measured and the radius guaranteed calculated in that way.

W. P. KENNEDY:—Just what is the service rendered by the boats?

HENRY R. SUTPHEN:—We get very little definite information as to this. One of the best proofs that we have of the work done has been by the illustrations in the English papers, particularly in the "Graphic." The boats are illustrated by an artist who is undoubtedly in that fleet of patrol boats; we see them pictured convoying battleships and looking for submarine bases in the Aegean Sea, operating in the North Sea, and doing all kinds of work which was never expected from them. They do have definite route work of patrolling, and they have been with the other patrol boats the means probably of driving the German submarine farther away from the coast all the time. This is shown by the reports of the sinkings. The submarine has to be on the surface a great part of the time in order to exist, and the patrol boats, operating in groups of six or eight, with airplanes, have proved of enormous service in fighting the submarines. The part played by the airplane is to drop smoke bombs, thereby locating the point where the submarine was last seen, and for the motor boat to circulate on the surface and endeavor to destroy the submarine by gun-fire and depth bombs.

H. W. SLAUSON:—How are the engines started?

HENRY R. SUTPHEN:—The engines are started by compressed air and are reversible. That detail, I think, is original on the Standard marine engine, which has had it for many years.

The engineers used to try stunts on reversing, and with a signal from the bridge for full speed astern they would go from full speed ahead to the engine starting in the reverse direction inside of two seconds.

M. W. HANKS:—Are any submarine detecting-devices carried aboard the boats?

HENRY R. SUTPHEN:—We do not know positively about that, but microphones, of course, are used very generally for detecting sounds under water, and I suppose these boats have them. They have other devices for destroying the submarine in addition to the gun that is mounted on deck and will shoot a 13-lb. shell.

AUTOMOTIVE NEEDS OF THE ARMY

THE members of the Society are naturally interested in all the military departments that will require automotive apparatus of any sort. This is true not only because they are engaged in the manufacture of such products, but also because a large number of S. A. E. members will be required to supervise maintenance and operation.

The Quartermaster Corps is probably the most important branch for the automotive industry to consider, from the standpoint of volume or numbers of units involved. The authorized army of a million men will require thirty to forty thousand trucks to handle the provisioning and transportation problems that arise at the front. The greatest efforts are being put forth to make the production of these trucks create as little disturbance in the industry as possible. There will have to be a number of changes from existing commercial practice in order to make the product thoroughly satisfactory and efficient for the trying military service.

In addition to transporting provisions and baggage, the Quartermaster Corps furnishes cars for the higher officer personnel. Both the trucks and these cars see the hardest kind of service, and the problem of maintaining such vast numbers of equipment in anything like reasonable condition will tax the resources in men of the wonderful station service which has grown up in this country.

The Signal Corps is in a class by itself as regards heterogeneity. Motor trucks are used for transporting supplies, and specialized trucks mount repair outfits for making minor and quick adjustments near the front. Other trucks mount radio apparatus. Bulky planes are carried on trailers, towed by the trucks attached to the hangar section, and last of all come trucks for transporting the extensive equipment of airplane engines. There are also special trucks for transporting, controlling and anchoring captive observation balloons.

For good reason the opinion has been practically unanimous that the products of European aeronautic factories have been superior to like products of this country. Working under the spur of warfare at their very doors, with every encouragement from their governments, and with the results of immediate experience always at hand, there is small wonder that European developments have far outstripped American practice; but now that we have become brothers-in-arms to those who are fighting so valiantly on the Allied fronts, and that their rich fund of experience has been so generously made an open book, American inventive genius should live up to its best traditions and produce types of machines equal in all respects, if not superior, to those developed abroad.

The Ordnance Department is carrying forward important development work on the motorization of field artillery. President George W. Dunham is the civilian member of a board having this development work in charge, and a large group of specialists has been called to help on the necessary modification of special types of tractors and other apparatus, which will be used to supplant horses in the transportation of guns as far as this may be found feasible. The Ordnance Department also will maintain a large number of special trucks for transporting ammunition, for making repairs in the field and for mounting machine guns. The handling and maintenance of all this equipment calls for men who have had responsible supervision, especially of commercial truck fleets.

The Medical Corps utilizes vast numbers of ambulances, which are divided into two general classes, a heavy machine which transports four people recumbent or eight sitting and a light vehicle capable of transporting two patients. This department has already gone far in the standardization of its equipment by concentrating its production in the fewest possible number of plants.

The Engineer Corps uses a few specialized trucks for transporting construction and trench-making machinery. The Quartermaster Corps, however, furnishes the rest of the trucks that transport the baggage and normal equipment of this as well as other branches of the army.

If the needs of all the government departments are to be met in a just and equitable manner, those who have charge of the automotive industry will have to steer a wide and straight course in order to avoid crippling the industry on the one hand or disabling the Army through lack of equipment on the other.

This is the work which, in large terms, the Society has set out to do. Months ago relations of confidence were established with the various government bureaus, and since that time there has been a steady flow of standardization and consultation work between official Washington and the Society's committees. The Society has always limited its activities to technical and scientific phases of the industry, so that for the purpose of handling business relations and questions of production the Automotive Committee has been organized and is endeavoring to supplement the work of the Society in an effective way.

The Farm Tractor as Related to the Food Problem

By H. L. HORNING* (*Member of the Society*) *Illustrated with* CHARTS AND PHOTOGRAPHS

LIFE can be defined as an energy cycle, the maintenance of which is only the struggle for existence. Physically, at least, life depends on an environment of heat, moisture, oxygen and pressure, and on a constant supply of energy called food. Food, therefore, is fundamental, and while a proper environment is not difficult to find, it must always be chosen in reference to food and water. Man's adaptability and understanding, called "civilization," has given him a wide choice of environment and made possible the populating and use of a large part of the earth.

The food problem revolves around the minimum food requirements as against the maximum area of arable soil; the maximum requirements of increasing population as against productivity per unit of area; the control of waste; and the use of an efficient diet.

An understanding of the tractor as a factor in the future of the human race involves a discussion on broad lines, and while it may seem like a divergence from the main theme, only the consideration of the food problem from physiological, social, political, and commercial, as well as agricultural standpoints, will lead to a true appreciation of its significance.

Whether our conception of the beginnings of the human race corresponds with the Biblical version or the Darwin theory, it is certain that early struggles for existence were principally against the elements and wild beasts, and not particularly for foods. The passage of time and the increasing area covered by the population of the world have accentuated the food problem.

Scientists assert that primitive man lived in a tropical region, where wild fruits and products were his sources of sustenance. Man's virility and power to adapt himself to conditions and to control the natural forces in ways best suited to his existence make it possible for the human race to multiply at a rate much faster at times than does its ability to command means to produce and distribute food. Civilization has its foundation in better methods and machinery for the accomplishment of this latter end.

*General Manager, Waukesha Motor Company.

FACTORS GOVERNING FOOD CONSUMPTION

The sum total of food required by the human race is governed by three main factors:—

1. Increasing population.
2. Rising standards of living.
3. Increasing social, industrial, and political activities.

Increasing Population

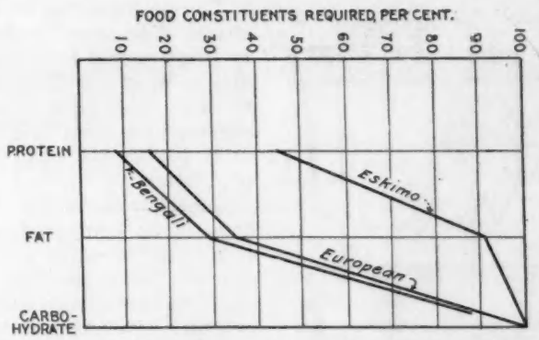
We can appreciate the increase in population best by reflecting that there must have been comparatively few men in prehistoric times. Now Europe is crowded. America and the Islands and the far North and South and East are becoming inhabited by an increasing population.

Standards of Living

As the masses become educated and learn the customs, habits, luxuries, of the cultured classes, their ambition to rise above the common level increases the demands on machinery methods and the systems of civilized society. The demand for food is affected because the consumption of greater human energy is required to supply better food, clothing, and all the elements of comfort and culture not demanded in the past.

Food is human fuel, and intense activities throughout the world, together with high wages and the introduction of women into many fields of manual labor, increase the appetites of the average man and woman. Easy money develops new appetites, and bulging pocketbooks foster waste never before possible.

The office man, requiring 2500 calories of food per day, enters war activities and must have 3500 calories. Those hitherto performing moderate labor requiring 3500 calories demand 4200 per day. Women, normally requiring 2300 calories, are put to man's work, and require 3100 calories. Men, women, and children eat too much when living under conditions of war-time prosperity, even though they do no labor requiring heavy food.



DIFFERENCE IN DIET BETWEEN COLD COUNTRIES AND TROPICS

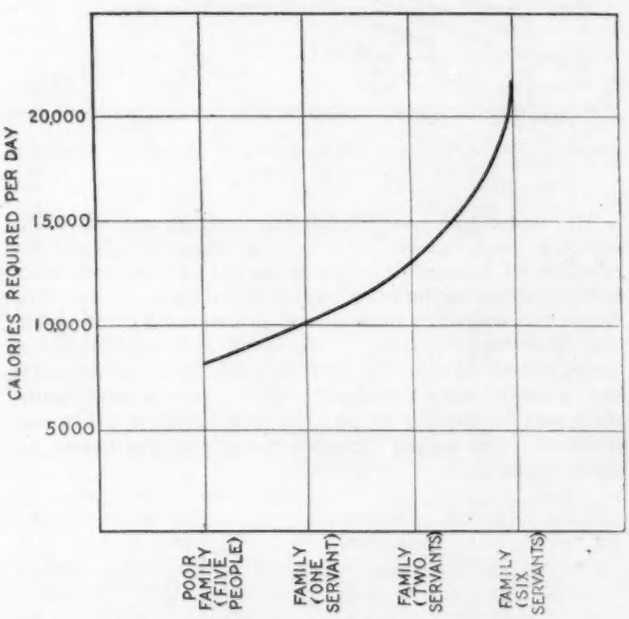
The total demand for food is not all legitimate; some of it rises from improper diets and eating habits and probably has its inception in nature's effort to provide a surplus against a "peak load," thus depending on the human body to store some and eliminate much. The influence of fifty years of peace has made for easy living. Doctors tell us the most prevalent chronic diseases are those arising from the breaking down of the resistance that enables the body to carry off waste and fight normal conditions.

The human machine, in the method followed by some of the vital processes, is analogous to the internal combustion engine from the thermodynamic standpoint, particularly in regard to the latter's economy curves. The internal combustion engine produces the greatest amount of work per pound of fuel when working at nearly full load, the greatest thermal efficiency being 25 per cent. At full load the economy is less, and at no load and intermediate points the economy is poor. In the human machine, experimental psychology and the Taylor system have shown that for each kind of work there is a load which, if maintained, will result in the greatest amount of work done for the least effort, and hence, in the food necessary to support life, the thermal efficiency of the human machine is similar to that of the internal combustion engine. With a full load, the work will be done inefficiently; with too little food, it will be done at the expense of the system. To carry the analogy further, into the realm of political economy, as the price of fuel increases owing to its scarcity and increased demand, the consumer tends to reduce the amount of fuel (food) necessary per human "horsepower." Likewise, as the price of food goes up his tendency is to increase the output per calorie. As a result of these two movements the common energy, food, tends to arrive at the same cost per calorie for different human beings. Nature so acts on people that they unconsciously buy food on a calorific basis.

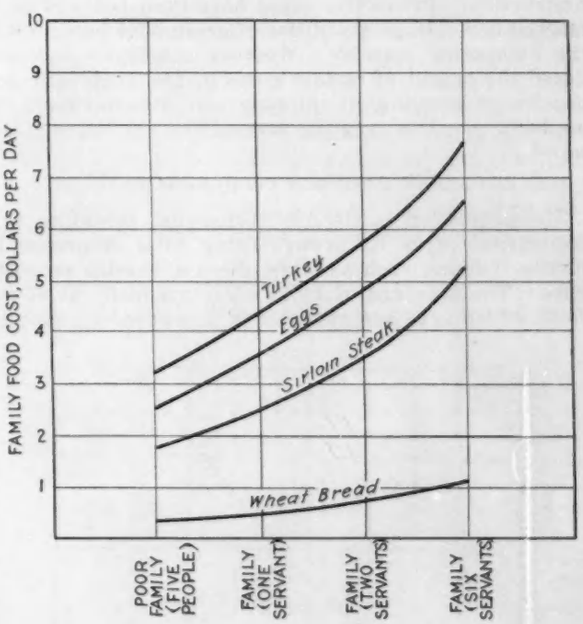
Increased Social and Political Activities

Social and political influences bring about great upheavals, such as the present conflict, call out great activities and make great drains on the food surplus necessary to keep up the fires of human activities. Political and commercial influences bring about the activity called prosperity, which quickens the pulse of the industrial life. The rapid circulation of money tends to produce the highest activity of mankind. Under these influences the average man is driven on to his best performance by the impulse to make hay while the sun shines, to live while living is easy, or to reach the height of a cherished ambition while the demands for skill are at high tide. The demands for food rise and fall with world-wide moral and intellectual impulses.

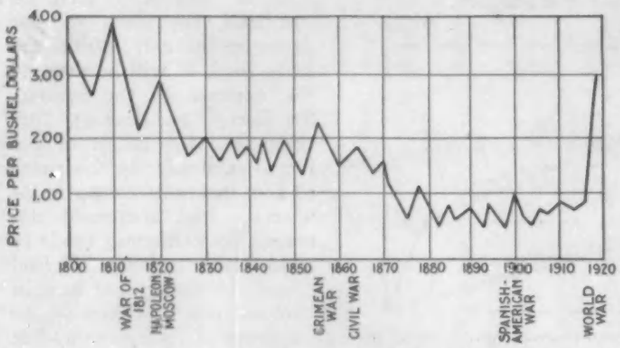
A condition of great political significance is had when food prices attain figures such that it is impossible to buy energy enough with a given wage to obtain food, clothing and the necessities of life. We shall face such



ENERGY REQUIRED TO KEEP VARIOUS FAMILIES



FOOD COST FOR VARIOUS FAMILIES



VARIATION IN FOOD DEMAND DURING POLITICAL ACTIVITIES

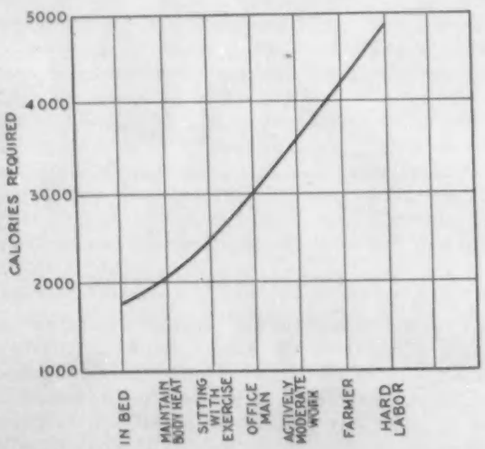
a condition in the future, unless some new means and methods are discovered for remedying the trouble.

Our recently passed Food Laws are intended to control this condition by every legal means, principally by lessening waste and by directing the processes of distribution. This effort is entirely for the purpose of keeping the cost per calorie of common foods in a reasonable relation to human earning power.

In the present struggle there have been many readjustments in methods of food distribution throughout the world. Millions of men have been taken from the fields to the trenches, from the activity of production to that of destruction. Productive areas have been hemmed in by martial law. Huge quantities of grain have been sunk in the submarine warfare. Weather conditions have reduced the output of certain parts of the world; the suspension or lessening of shipping activities has made the products of other regions unavailable to the civilized world.

VARIATION OF FOOD DEMAND

The population is steadily increasing, according to a geometrical ratio, its growth being little influenced by adverse factors, such as wars, disease, famine or pestilence. The standard of living rises gradually as educational advantages are available to down-trodden peoples.



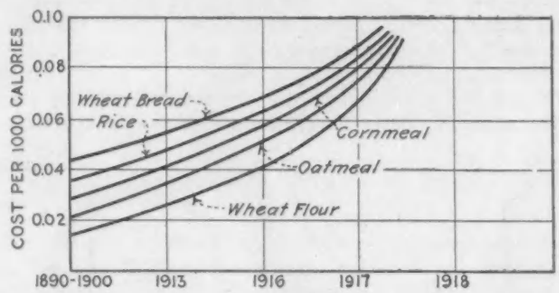
DAILY ENERGY REQUIRED FOR VARIOUS ACTIVITIES

Increasing population and higher standards of living result in increased demands for food, inasmuch as all human demands, whether for culture, protection from the elements, travel, study ,or physical activities, can be measured best in units of food.

The problem can be represented by the accompanying chart. The lengths of the three sides can be considered as proportional to the population, the standard of living, and to what can be called activity. At various times all three of these factors increase. The volume of the block, representing calories of food consumed, is increasing at a much higher rate than the length of the side representing population.

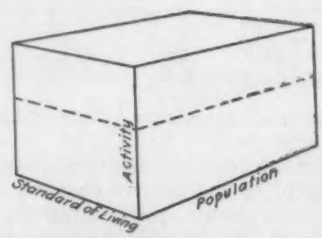
Generally speaking, the more rapid increase in food demand as compared with the means for meeting it, results in increased price of foods and in such great incentives for production that every available piece of soil becomes intensively cultivated. After that an economic pressure develops that drives men to other homes, to overthrow dynasties, or to change the direction of national life.

These are the tendencies in the old countries; in new countries like ours, the population increases and the cultivated acreage spreads until finally the demands for food become such that an increase in mere area hampered by old methods will not offset consumption.



SHOWING TENDENCY OF CARBOHYDRATES TO APPROACH CONSTANT COST PER CALORIE

The world had been struggling in darkness when the printing press came, and Europe was suffering from pressure of population when a change in the methods of navigation made the discovery of America possible. The world was demanding more certain means of communication than ships driven by the wind and the steamship came; communication by land was too slow for the times and railroads were developed. It was necessary to know what was happening across the seas and the cable was invented. The reaper replaced the scythe, the threshing machine the flail.



CUBE SHOWING VARIATION OF FOOD DEMAND (REPRESENTED BY VOLUME) WITH HUMAN ACTIVITIES

The history of man has been made up of one problem after another, of which, from a mathematical standpoint, a successful solution seemed entirely impossible. Time and again the problem has been met by man's superiority over all other forms of life and his ability to develop and apply new methods.

EFFECT OF TRACTOR ON SOIL CONDITIONS

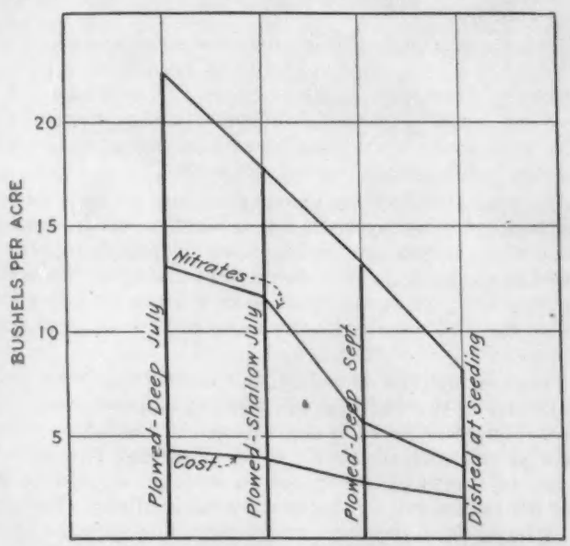
The fecundity of the soil can be measured roughly by the cubical contents of the seed bed. Intensive cultivation depends on better physical preparation of the seed bed, together with a correct chemical balance and moisture for the crop to be raised, all operations on the soil being so timed as to bring soil activity, climate, and plant growth into harmony.

These problems of increasing the depth of the seed bed, improving its physical and chemical condition and taking advantage of the right time of the year from the standpoint of moisture and bacterial activity indicate that the tractor is potentially the best means of production for meeting the food problem. The tractor is particularly effective in raising the energy foods. An analysis of the average diet indicates it will enter into the production of 54 per cent of the energy foods.

ADVANTAGES OF TRACTOR FARMING

Tractors make farming possible on a business basis. Among the many advantages of tractor farming are the following:

1. Many farms can be made to increase substantially their crops, as the tractor can bring up 1 in. more of the virgin soil than the horse has ever been able to turn over.

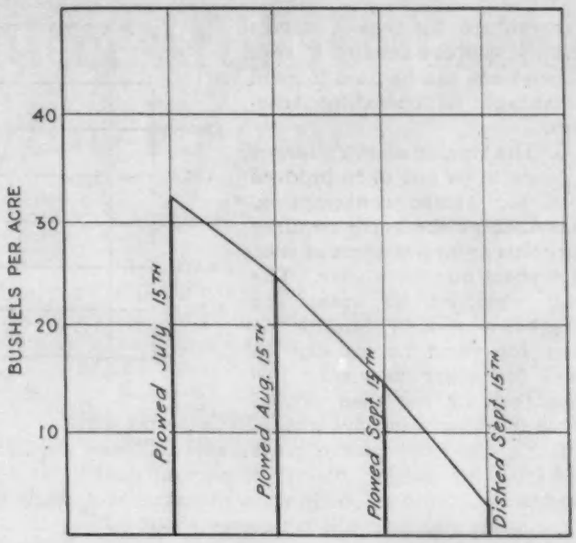


EFFECT OF DEPTH AND TIME OF PLOWING ON WINTER WHEAT

By turning over 1 in. more the following year, the soil can be further improved. Many crop outputs can be increased 20 per cent by these methods. Some soils do not lend themselves to an increased output by means of subsoil cultivation, as the top soil is only 7 in. deep.

2. On many farms very deep plowing is required in order to bring up the good subsoil and thus to reclaim worn-out land. Such overworked farms are found in New York and in the New England States.

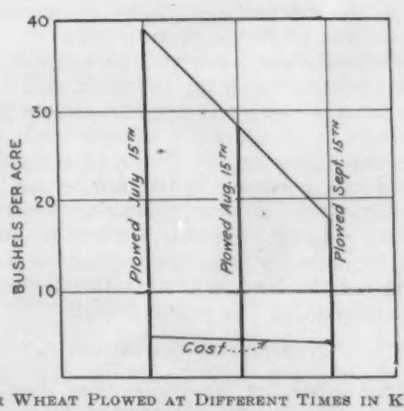
3. A tractor allows a farmer to make the most of a good day, by plowing three times as much as with horses. He can also harvest at such high speed that grain can be cut at exactly the right time and thus its maximum food value can be retained. The tractor will also save a substantial proportion of the crops of some of the Northern districts, in which the season for growing is comparatively short and the shortage of farm labor makes it impossible to harvest the crop before winter.



WINTER WHEAT PLOWED AT DIFFERENT TIMES—DEPTH 5 IN.

4. The tractor will increase the output per man on the farm, so that it is at least three times that possible with horse methods of cultivation. This is particularly interesting at this time, when there is a shortage of 2,000,000 men on the farms of our country.

5. Tractors, when used for July plowing in the winter wheat belt, will increase the output greatly; depending on various conditions, this crop will be as much as five times what would be obtained with the September plowing. Tractors can be used in the hot month of July, when it would be impossible for horses to live for any effective work, even for a very few hours a day. In the month of July, the condition of the soil is correct, from a chemical standpoint, to produce a strong sprout and effective roots.

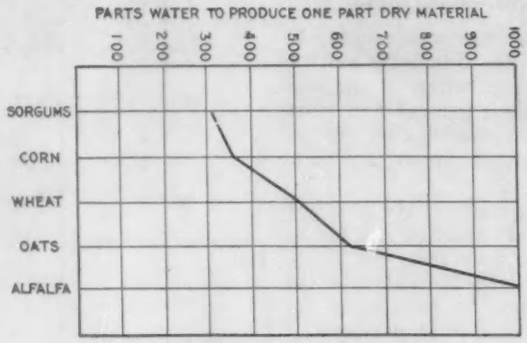


WINTER WHEAT PLOWED AT DIFFERENT TIMES IN KANSAS—DEPTH 7 IN.

In July the rainfall over the wheat belt is such as to help the condition of the soil in producing a hardy grain growth which, in September and the dry months of the fall and winter, will be able to withstand the lack of moisture, the wind and cold. The tractor, because of its increased output per day and per man, allows the total plowing on the farm to be done within a period (some time in July) which gives the most effective yield. The tractor can work twenty-four hours per day if necessary, while the horse can only work a maximum of four. The science of agronomy, which considers rainfall during season, sunshine, wind, the chance of drought, evaporation

temperature, the type of storms and the average amount of rain at one time, can be used to good advantage in operating tractors.

6. The tractor allows a larger acreage to be put in to produce food for human consumption, inasmuch as the horse requires the crops from five acres of land to support him for a year. The land required to raise the thirty-five million bushels of food for farm horses can be used for other necessary human food or for food of the horse in other work for which he is better fitted.



WATER REQUIRED WITH VARIOUS CROPS

7. Figuring the cost of power derived from the horse and from the tractor, it is an important distinction that the tractor costs very little when standing idle, while the horse when standing idle consumes about 80 per cent of what he would when working at full load.

8. The tractor has a distinct advantage over the horse in the amount of time required for upkeep. It takes one-third the time to keep a tractor in first-class condition that is required to keep horses.

9. The tractor makes possible the cultivation of new territory that could not be properly handled by horse-plow methods. It makes feasible the use of some soils that could not be made to produce by horse-plow methods.

10. When figured properly, tractor plowing can be done for one-third the cost of horse plowing.

11. The tractor will take the place of a great deal of farm labor. On a farm of from 500 to 1000 acres a tractor of proper size will replace from two to three laborers; on a farm of from 160 to 500 acres, it is possible to replace one farm-hand at least.

12. A tractor of proper size on a 500 to 1000-acre farm will do the work of eight to twelve horses; on a 160 to 500-acre farm, of five to seven horses.

13. At harvest time there will be a saving of 30 per cent of the time required to do the work with horses.

14. The tractor has many applications on the average farm in which it is far more efficient than the human hand. As time goes on the range of tractor activities on the farm will increase. It can now be used in cutting feed, sawing wood, driving threshing machines, road building and reaping harvests. Irrigating projects are made easy by proper tractor application, as is the crushing of lime for the land in certain territories, in which this useful element of the soil is found.

Tractors in Operation

The tractor is turning the drudgery of the farm into a work of pleasure. The Department of Agriculture, as a result of an investigation made by some 32,000 of its agents, estimated that in the neighborhood of 35,000 tractors would be in successful operation at the beginning of the 1917 spring plowing.

This represents only 4½ per cent of the horsepower used on farms for plowing. It is expected that by the end of this year 80,000 tractors will be in operation, and even then 89 per cent of the power on the farms will be furnished by horses.

SUGGESTION FOR INCREASING FOOD SUPPLY

If tractor manufacturers are assisted by methods that are possible under present circumstances, the output can be increased so that by June 1, 1918, there will be in operation 150,000 tractors, which would represent 20 per cent of the horsepower used on the farms.

It would be possible by the proper application of these tractors to increase the small grain crop to the extent of one thousand million (1,000,000,000) bushels each year.

By proper government supervision the new tractors and the old can be made to produce over twice their normal output, owing to the fact that tractors can work twenty-three hours per day instead of their usual eight hours, and the season of useful work days can be 150 instead of 50 days. There is no end to the increase of food production that could be brought about by the proper administration of tractor farming.

The food shortage for the coming year is only preliminary to the shortages of the coming seasons. Economic conditions that will exist throughout the world from this time until two years after the war will be such as to prevent the return to normal prices of food and other commodities.

The tractor industry is now hampered and cannot do its duty in solving the food problem, because of conditions resulting from our national crisis. The production of tractors could be at least doubled with the present facilities if factories could be supplied with material and labor for the fulfillment of present demands.

The tractor therefore, when exercising its full function, can revolutionize agricultural methods. It is time for something of the sort. The flood of population to the cities has gone on until a shortage of 2,000,000 men exists on the farm. Volumes have been written by economists and students of sociology on the migration of rural population.

This new method of agriculture must go on through an evolution, to the end that agriculture will not mean serfdom. There is no such oppression as chores; no prison term as irksome as the lot of the farmer's life without means of access to town; and no serfdom so hard as the long hours and toil on the land by old methods. Farming must be made so pleasant, profitable, so close to the pleasures of the city, so near the markets, that it will be a vast business instead of a prison sentence.

The rural free delivery, the telephone, the automobile, the motor truck, are all bringing a new life to the country. The tractor must bring democracy to the sons and daughters of the soil. It must set them free to enjoy life, liberty, and the pursuit of happiness.

The tractor has come at a time when the food demand has reached a peak. The activities throughout the world have brought the problems of maybe fifty or twenty-five years ahead to our attention. We must meet these problems by different methods. The different method in the case of agriculture is the tractor. It can plow more deeply, it can plow at the right time, it can plow all the time. It is a new method that will solve the food problems that must arise in the next few centuries.

Note:—The author desires to acknowledge his appreciation of the information received from such authorities as Lusk, Mendel, Chittenden, Taylor, Eltzbacker, McVey of the Capper Publications, Parlin of *The Country Gentleman*, the Department of Agriculture and many others.

Fundamentals of a Successful Kerosene-Burning Tractor Engine

By C. E. SARGENT* (*Member of the Society*) *Illustrated with* CHARTS

THE conservation of liquid fuel is the most important subject in the automotive industry of today. The ever increasing and unprecedented demand for gasoline for the internal-combustion engines used on trucks, tractors and automobiles has about equalled the world's output, so that the futude development and stability of this industry will depend on the furnishing of engines adapted for the heavier hydrocarbons, such as kerosene or fuel oils.

The birth of the automobile industry and the beginning of its development took place when gasoline was a drug on the market. Naturally engines were designed to use this fuel, which was so cheap that efficiency was given little consideration.

Mechanically, the gasoline engine has been improved. The construction, workmanship, turning moment, port area, balance, oiling system and explosion space have been bettered, but thermodynamically the standard internal combustion engine of today has the same cycle, the same heat losses, the same limitations, and the same inability to use successfully kerosene and non-volatile fuels as it had when the fundamental Otto patent expired in 1893.

We will review briefly the cycle of operations of a standard gasoline engine in order to comprehend its limitations and the possibilities of using a less volatile fuel than gasoline and less fuel of any nature than we are now using. A four-stroke cycle engine running at full power compresses a cylinder full of combustible gas, drawn in on the suction stroke, to a point just below the critical pressure of spontaneous ignition. This gas is then fired by a spark. The heat of the chemical action taking place tends to increase the volume. The gas is confined, however, so that the heat increases the pressure of the burning charge, which delivers to the piston an average pressure during its working stroke of from 80 to 100 lb. per sq. in.

LIMITATIONS OF PRESENT ENGINES

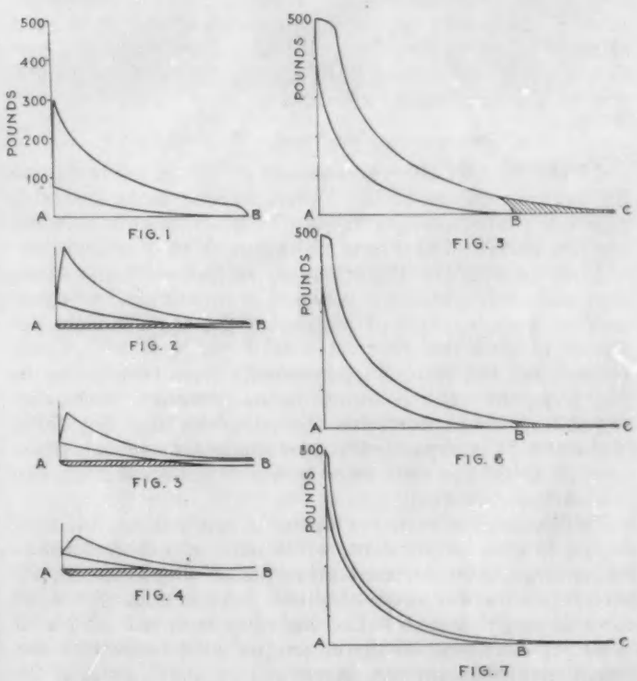
The efficiency of such an engine at full load is limited first by the low compression, as, other things being equal, thermal efficiency increases inversely as the cooling surface of the cylinder walls during inflammation. Kerosene, while less volatile than gasoline, even though it has more heat units per pound, "prematures" as a gas, with a lower compression.

The second loss is caused by releasing the burning gases at an absolute pressure three times as great as it was before compression, eliminating the benefits of expansion so essential for efficiency in other heat engines.

The third loss, and the greatest limitation to the efficiency of the present tractor engine, this applying to truck and automobile engines as well, is due to the method of reducing the mean effective pressure when developing only a light or idling load. In order to fill an engine cylinder with combustible mixture when its greatest possible output is desired, large inlet valves are provided; yet when less than full load is required, which is most of the time, the gas is throttled by hand or by a governor. This not only reduces the compression so essential for efficiency, but puts a back pressure of as much as ten pounds per square inch on the pistons. As a result at least ten per cent of the power of the engine is required to overcome the braking effect inherent in this form of speed control. Controlling by throttling the intake is a method both simple and cheap, but, as was the case in the early steam engines, is not conducive to economy.

Disadvantages of Throttling Control

Throttling steam engines were as much of a standard as are our present gasoline engines until George H. Corliss offered to supplant the existing engines then running mills and factories, with an engine of the cut-off Corliss type, taking for pay one-half the saving obtained in three years' operation. So great was the increased efficiency of the Corliss engine that except for installations in which fuel was a valueless by-product, throttling steam engines passed with the nineteenth century. Not only is a



FIGS. 1 TO 7—INDICATOR DIAGRAMS OF HEAVY-DUTY ENGINES

Figs. 1, 2, 3 and 4 are for standard gasoline tractor or truck engine at full, ¾, ½ and ¼ load respectively. The inefficiency of this engine is explained by limited compression, high terminal pressure at full load, Fig. 1, and back pressure from wire drawing, or throttling, which increases inversely as the load, Figs. 2, 3 and 4. *AB* represents both the induction stroke and piston travel.

Figs. 5, 6 and 7 show diagrams from Diesel engine having constant compression of 500 lb., irrespective of load, the m.e.p. varying with amount of fuel injected. *AB* represents the length of the induction stroke. If *AC* represents the piston travel, the shaded portion will show the gain from complete expansion.

*Chief Engineer, Lyons-Atlas Company.

throttling engine conducive to inefficiency with the best of fuel, but the method of controlling the speed or output makes the use of any but a highly volatile fuel impracticable. Throttling the induced charge lowers the compression, the disadvantages of which will be referred to later, and besides putting a brake on the engine, thereby increasing the fuel consumption per unit of output as the load decreases, so rarefies and cools the charge in the inlet manifold that the fuel, even much of our present so-called gasoline is precipitated.

High-powered multicylinder engines, which "idle" with a lower absolute pressure in the inlet manifold and cylinders than do engines with fewer pistons and less piston displacement, show a greater loss from precipitation. The fuel thus lost either works by the piston rings to the crankcase or goes out the exhaust unburned.

DIFFICULTIES IN BURNING KEROSENE

Kerosene properly atomized and heated to about 350 deg. fahr. will remain a perfect gas, but if such a condition is reached at full load the temperature will be reduced as the load become less, owing to the exhaust-manifold stove losing its heat and to the cooling effect of throttling. As it requires less than 500 deg. fahr. rise of temperature of the induced charge to cut the capacity of the engine in half, we see that the adapting of a gasoline engine to the use of kerosene is a problem that has not yet been satisfactorily solved.

Burning kerosene commercially in a gasoline engine will never be accomplished until the temperatures of the induced charge can be maintained constant automatically, irrespective of the exhaust temperature, compression and cooling effect of throttling. Even if this can be accomplished the engine capacity will decrease as the temperature is raised to the point necessary for obtaining a perfect gas. Regulation by throttling, then, is not conducive to the burning of kerosene.

Gain from Full-Stroke Expansion

At the time of the development of the gasoline engine for vehicles the reduction of weight was more desirable than low fuel consumption, just as is the case in aviation engines today. There was no incentive to fuel economy, so that, as with the steam engine in Newcommen's time, expansion was untried. When fuel was cheap and automobiles were luxuries of the well-to-do, engines were designed to give the greatest output per unit of weight. To this day the terminal pressure is from twenty-five to thirty pounds above atmospheric pressure with corresponding temperatures of from 1200 to 1500 deg. fahr. If the charge is expanded to practically atmospheric pressure, 23 to 26 per cent more power is obtained from the same amount of fuel.

The thermal efficiency of present engines at full load seldom attains 20 per cent, while with an expansion corresponding to 50 per cent more piston displacement, 25 per cent is the minimum obtained. An engine with a 50 per cent longer stroke but of the same bore will weigh 15 to 20 per cent more than the engine with two-thirds the piston displacement, but there will be a net gain of 25 per cent more power from the same fuel, the exhaust will be cooler and the average temperature much less during the working stroke; also the cycle will permit of a speed control that eliminates the back-pressure caused by throttling of the present automotive engine.

Such an engine at full load completely expands the burning gas, reduces the exhaust gas temperature 1000 deg. fahr. and changes into work the heat that has previously disappeared. Such an engine will be more expensive than the shorter-stroke engine doing the same work, but the first cost of an engine comes but once, while the burning of the fuel is a continuous operation. The heavier or the less volatile the fuel, the more poorly it is atomized. Therefore a more perfect combustion will be obtained if the burning charge is retained longer before exhaust occurs. As previously stated, in the ordinary engine the volume of gas released to the exhaust is less than the volume compressed; with a slow-burning mixture

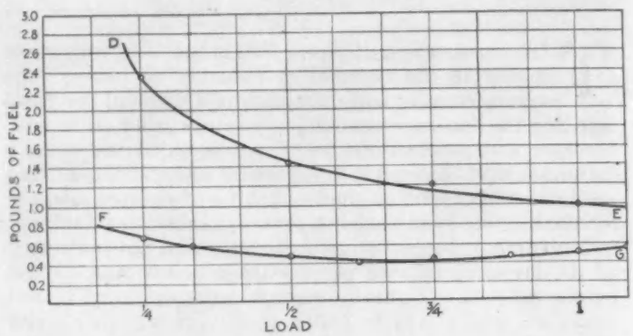


FIG. 8—CONSUMPTION CURVES OF GASOLINE AND DIESEL ENGINES

The curve *DE* shows average gasoline consumption in pounds per b.hp. hour of six different tractor engines. The curve *FG* shows the pounds of fuel oil consumed at different loads by a four-stroke cycle engine of the Diesel type in which the induction and compression strokes are the same. The commercial efficiency of the latter is more in evidence when it is considered that fuel oil costs about 1/5 as much as gasoline.

it may release much fuel in the form of smoke before complete combustion. The advantage then of a working stroke 50 per cent longer than the compression, is more apparent for heavy fuels when complete gasification is questionable.

Effect of Compression

Even with the limitation of back-pressure removed and the benefits of complete expansion utilized, the method of mixing the fuel with the air during the suction stroke has the disadvantage that the compression pressure must be less than that causing premature ignition.

Gas engines, similar to some of the first ones constructed, with no compression, require five times as much fuel as engines compressing to 80 lb., and alcohol engines with 200-lb. compression will deliver a horsepower on nearly half the heat units consumed in the gasoline prime mover.

We see therefore that efficiency increases with compression, although the critical pressure of spontaneous ignition must never be reached. The Diesel engine, which compresses only air to 550 lb., requires about half the fuel per horsepower-hour that the ordinary tractor and truck engines use. Engines of the Diesel type not only show a higher efficiency than gasoline engines, but as they compress the air until it is red-hot, any fuel properly injected into the air will burn and increase its mean effective pressure in proportion to the fuel supplied. Not only will engines of this type burn the more volatile oils, but kerosene fuel and even crude oil will be consumed with hardly a trace of smoke.

Improved Diesel Engine Design

Diesel engines have heretofore required air compressors and high air-pressure for the successful atomization of the fuel. Recent improvements, however, have eliminated compressed air and compressors, the high thermal efficiency being maintained. Not only do we obtain more horsepower output from a unit of fuel with engines of this type than with the present truck and tractor engines,

but on account of regulating the horsepower output by reducing the fuel supply instead of reducing the mixture by wire-drawing the charge, there can be no back-pressure on the pistons with light loads; therefore, such an engine is far more preferable for truck and tractor work than the present type. It can be started by hand or by an electric starter, just as the gasoline engine is started, because the compression is permitted to take place only when the flywheel has obtained sufficient inertia to produce the requisite compression.

The burning of low volatile fuels eliminates all fire risk, and on account of the method of introducing the fuel and igniting it, carbureters and magnetos have no place in such a powerplant.

A cylinder full of air is compressed for full or light loads and the terminal pressure is always higher than the pressure before compression. At full loads this may be 45 to 50 lb. absolute and if we attain the firing temperature and pressure by compressing two-thirds of a cylinder full of air and expand the charge to full stroke, the thermal efficiency will reach at least 37 per cent and may even reach 40 per cent under favorable conditions.

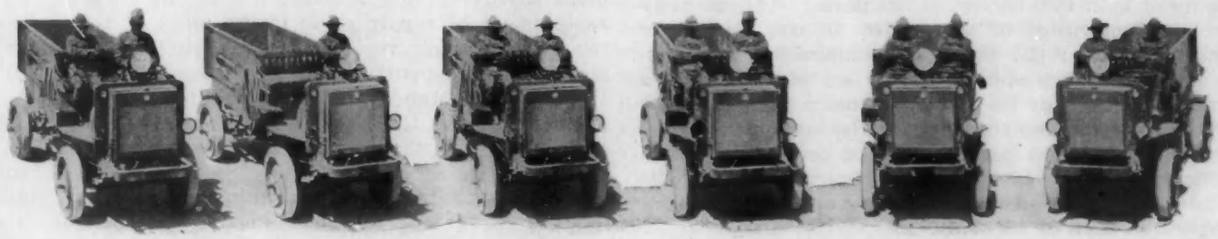
We see then that we not only can produce the same horsepower output on half the number of heat units with an engine properly designed for trucks and tractors, but we can use a fuel costing from one-quarter to one-fifth as much as the gasoline of today. With such engines we will conserve the fuel supply, eliminate the fire risk, burn almost any hydrocarbon, whether mineral oil, animal fat, peanut oil or tar. We will require so few accessories to our powerplant that the first cost will be less, even though the engine weighs a little more.

DESCRIPTION OF IDEAL TRACTOR ENGINE

The ideal tractor engine then—and it is almost real—is one that compresses pure air to a predetermined pressure sufficiently hot to ignite the fuel when introduced, one in which the power and speed can be reduced without the introduction of back-pressure, in which the fuel used varies with the load and the burning charge is expanded to a greater volume than the volume of the air compressed.

Every feature embodied in the description of the ideal engine has been attained. The actual use of these features, now under way, will result in an engine that will develop a horsepower on half the heat and at less than one-quarter of the cost of that required by the standard tractor engines now in use.

LESSONS OF THE WAR IN TRUCK DESIGN



By W. O. THOMAS* (*Non-Member*) *Illustrated with* PHOTOGRAPH

THE trucks used in France by the British Army at the beginning of the war were mostly of the commercial type not especially designed for war service. This was true of the trucks made in Europe as well as those sent from America. A very small number of the so-called subsidized British War Office pattern had been built, but the majority were taken out of regular commercial service. Many of them had been in use as omnibuses by the London General Omnibus Company and the bodies were replaced by others quickly built to meet the emergency. Some of the European-built trucks were fitted with four-speed transmissions of the commercial type in order to permit the use of smaller engines and greater fuel economy.

The English and American trucks consisted of about nineteen different makes and forty-two different models of widely varying design, so that the problem of providing spare parts and maintaining the trucks in service soon became very great. The makers were working overtime producing new trucks and there was a consequent shortage of spare parts.

My first study of the maintenance problem showed that some vehicles had been out of service from three to five months and that a large number of one of the American trucks, which were in general giving good satisfaction, were out of commission on account of shortage of clutch thrust collars, gearshifts, fan bearings and front wheels. It was soon evident that most of the trouble was not with the main points of design but with gear ratios and other minor details.

*Thomas and Thomas, Consulting Engineers, Detroit.

MOTOR TRANSPORT IN ENGLAND AND FRANCE

It must not be supposed that an ideal war truck should be something not adapted to general service conditions. The constant heavy duty under which the war truck is operated must produce a simpler, more reliable and more easily maintained truck for use under ordinary commercial conditions. The war truck is generally operated by a man who has never driven a truck before and who probably has never even driven a touring car. He is recruited as a soldier and afterwards trained as a mechanical transport driver. In the English Army he is a private in the Army Service Corps, and the officer over him is also likely to be new at the truck work.

The English Army Service Corps deals mainly with the problem of feeding the men and horses of the army. The transporting of the food came under an Army Service Corps officer called the Director of Transport and Supplies, and the transport work by horses meant principally the addition of a little more forage. When the horse transport was superseded by motor trucks the system still remained under the control of the same officer, although he had had little mechanical experience. The

problem gradually changed to one of mechanical operation and maintenance but in the English Army the administration of it is still an adjunct to the Commissary.

In the French Army before the war the use of motor vehicles was much further advanced and was part of the artillery command. The officers in this command were technically trained and well equipped for the problem, but in both the English and French armies it was necessary to call in men who had had previous engineering experience along automobile lines. Personally I can see the need of keeping the mechanical transport operation and maintenance separate from the older departments of the army, although it might be possible to combine the maintenance facilities of the automobile, motor truck and aeronautic sections.

The training of the army personnel in the use of mechanical transport is important in order that the trucks in use may be properly operated and maintained. The men, as well as the trucks, need steady reinforcements and replacements, amounting to three per cent per month even after the army is complete in the field. Besides these additional men under training, two months' reinforcements must always be available at the advanced base, and two months' reinforcements at the base, where they can undergo additional training until they are called.

The training of a transport private or officer takes about three months in addition to the time required for his training as a soldier. It is necessary to divide the training of both into three distinct parts: (1) the ordinary book knowledge of the subject in the Mechanical Transport School; (2) driving and operation; (3) system of maintenance and repair. I am satisfied that a thorough training of the personnel more than pays for itself in the improved condition of the equipment afterward, and that what has been found necessary in this direction should be given careful consideration by the United States Government in building up the mechanical transport division of its army.

It is difficult for the average engineer and writer to compare European trucks at the front with those sent over from America. They are good and bad from entirely opposite standpoints. The European trucks for the main part were better designed in detail and much more refined than the trucks sent from America, but their parts were not nearly so interchangeable, and it was more difficult to repair them on account of the hand-fitting that is an essential feature of the system under which they are manufactured. The parts of some of the American cars and trucks were interchangeable to an extent beyond the comprehension of the average British or French officer.

REPAIR PARTS IN THE FIELD

To maintain trucks in the field the English army ordered parts for every truck varying from 10 per cent of the total of all of the main units of the trucks in use to 100 per cent of all nuts, bolts, carbureter floats, bearings, washers, brake linings, gaskets, clutch facings, etc., and 200 per cent of all spark-plugs, fan belts, hose connections, etc.

After the trucks had been used for some time a monthly list was prepared for the parts which experience showed were needed to maintain the trucks in service. This list was known as the 3 per cent list because it contains 3 per cent of all main units in service and up to 100 per cent spark-plugs, etc. A stock of these parts equal to a six months' supply is carried at the various bases. This stock besides being added to by the regular 3 per cent monthly list can draw in emergency from the reserve stocks at the base, which are replenished by special orders.

While 3 per cent of the main units are assumed as required in an assembled condition each month, all of the separate component parts of these units are also carried in an additional proportion, for instance, crankshafts are an additional 3 per cent, bearings from 10 to 30 per cent, etc. About 2 per cent per month of the complete trucks in service are also replaced with new trucks on account of being beyond repair with new units or parts.

If all of the above allowances for repair and replacement be used up in any given period and charged at the same rate as the parts in the original truck, the value of each original truck will have been entirely doubled after about eight months' service. Actually the parts replaced are always enough to maintain more than a balance, so that the nominal life of the truck covers a slightly longer period. With this life, the investment for trucks and replacement parts f.o.b. factory averages about $16 per day per truck in service, which for war conditions is a creditable showing for mechanical transport.

STANDARDIZATION OF MILITARY TRUCKS

The need of standardization of parts cannot be too strongly emphasized. After going through this problem under actual war conditions it is easy to realize the enormous saving of time and expense in the shipment and replacement of repair parts if the units of the various trucks are rapidly replaceable by having their main dimensions and supporting points standardized. Personally I feel that the standardization should be carried out even further because the problem in the field is to repair quickly the unit that has been removed from a truck.

I remember seeing in France 180 cars of one Detroit make all with the same complaint. They were ready for use except for one gear in the transmission, and a condenser. Some of them had never been in service but had been robbed for the repair of others at the front.

On another occasion I was able to supply a differential intended for a passenger-car axle as a repair for the countershaft of a fire truck, which otherwise would have been out of service for a long time. In England today under government control many companies are using detail parts belonging to other cars and trucks without the necessity of making additional dies and tools. My impression is that much time would be saved by starting out at once to standardize along this same plan.

Advantages of Unit Design

In order to standardize effectively, the government must assume the responsibility for the design used, for the distribution of the material of the proper quality, and for the manufacture of all forgings and similar parts needing dies and special tools. Such a design should be "unitized" to an extent not hitherto possible. For instance, the clutch housing should support the clutch operating mechanism, the transmission unit should be integral with the gearshift, and all operating mechanisms should be integral with and supported upon the units they control and not be separately supported on the frame. Much of the derangement of parts caused by damage to the frame itself would be thus avoided.

Care should be taken in the adoption of a standard that all of the parts are inclosed and protected against mud and weather. I have seen an artillery ammunition park, ready to move toward the front, stationed at the

roadside for such long periods that it was necessary to tie up the brake mechanism with canvas and to cover the radiator, wheels and other exposed parts in the same way to prevent them being rendered inoperative by the splashing of mud from other passing vehicles.

The English Army uses principally one size of truck of 3-ton capacity, somewhat larger than the United States Class "A" truck. Smaller trucks are called for to handle hay and oats, as these do not weigh so much as some of the other stores. In practice, however, these loads are bulky and are carried in the largest body available.

The French standard trucks are of 2 and 5 tons' capacity, the 2-ton truck being somewhat smaller than the Class "A" and the 5-ton truck being about the same as the Class "B" truck.

SPEED AND ROAD REQUIREMENTS

The trucks are normally operated at from 12 to 15 m.p.h., but the governors are usually set to allow of a speed of 18 to 20 m.p.h. in an emergency. Very often the governors are disabled, and many trucks are not provided with governors at all.

Most of the trucks in France are geared so that their engines will operate continuously at 18 or 20 m.p.h. on high gear in emergency. They are also required to operate on second gear up to a normal speed of 12 m.p.h. so that in an undulating country the convoy is not spread out by vehicles slowing up on the hills. The later trucks designed have a reduction of fifty to one on low gear in order that they will maneuver on low and reverse under bad road conditions without its being necessary to race the engine in starting.

It is found in practice that even the axles do not suffer as much by this extreme reduction as they do from racing the engine and letting the clutch in, as is necessary with some older type trucks sent from America.

Many trucks were geared too low on high to stand the test of high engine speeds in emergencies and these naturally developed engine trouble and broken crankshafts. All of them were geared too high on low and reverse to operate successfully under the bad road conditions which were constantly being made worse by the German shells, with the help of the heavy rains and floods.

Road Clearance Insufficient

Many of the early trucks were found wanting on account of insufficient road clearance. This has been remedied in the later designs by the adoption of transmissions with the countershaft placed sidewise of the main shaft, by double-geared rear axles, and by the use of heavier and smaller diameter flywheels than formerly. The ground clearances demanded in the United States specifications are approximately what have been found necessary in practice in France.

ENGINE DETAILS SHOULD BE IMPROVED

The engines of American trucks in France often gave trouble from the fact that they were not sufficiently run in before they were put into hard service. The engines must be of a heavy-duty type designed and balanced so that the truck can be run at a continuous speed of 20 m.p.h. on high gear in emergency.

The war has developed more improvements in engine details than in general design. Plain bearings without oil grooves have come into much more general use. The use of floating piston-pins and floating connecting-rod upper bushings has also come to stay. Many fixed piston-pins in engines giving serious trouble have been replaced in the field with floating pins, which have plain cast-iron stoppers to prevent the steel pins rubbing the cylinder sides.

Valve push-rod roller pins have also been replaced in the same way with floating pins, and in general the lesson has been learned that for heavy service a floating pin or bearing is not only more easily replaced in the field but shows much less wear than a fixed surface with concentrated pressure on one point.

The rear bearings of engines suffer considerably from the overhanging weight of clutches and universal-joints and from the pressure caused by the non-alignment of annular bearings with engine bearings in the case of inclosed unit clutches. The latter trouble is especially evident when the engine bearings have been re-scraped and taken up, and occurred to such an extent that I am convinced of the need of the complete separation of the clutch from the engine unit. The universal-joint can then be brought up close into the fly-wheel, which in turn should also be carried well forward so as to overhang the rear bearing as little as possible.

The removable-head cylinder block is receiving considerable attention from European engineers on account of the advantage of completely machined surfaces, the need of cleaning after continued service, and the ease of grinding the valves. In at least two new designs an overhead camshaft and valves are being used in conjunction with a removable head.

Pistons without ribs and with more liberal bearing surface above the piston-pins are in evidence. In some cases repair pistons have been made with one of the rings down close to the piston-pin in order to allow of more bearing surface above. The increased surface allows more liberal clearances and tolerances in replacing pistons in worn cylinders and materially decreases piston knocks.

Three-point support of engine is necessary: the supports should not be over 26 in. wide on account of the need of narrow frames to allow for the small steering radius. The supports of all sizes of engines should be the same, as it is necessary sometimes to use a larger engine in a special-purpose truck.

Valve Mechanisms

It was noted that many valves broke in the portion recessed for the valve-spring retainer. Many of the foreign engines have a recess ground to a curve to avoid sudden change in section, as it is impossible to allow for a proper fillet except with a large valve stem. The bearing-surface areas of overhead-valve parts are seldom liberal enough. Here again floating-pin and ball surfaces show less wear than fixed surfaces.

Adjusting nuts on valve lifters or valve stems do not stand up under the repeated hammering of war service; the best system noted is to provide small caps that cover the valve-stem ends and hold thin stamped shims for adjustment of the clearance.

Valve springs on certain makes of engines break without apparent cause. On these the trouble was often removed by making taper springs, which would indicate that the breakage was due to vibration set up in the spring itself.

The marking of the flywheel often causes confusion in the setting of the valve-timing, etc. No marks other than the top dead-center of No. 1 cylinder should be put on the flywheel.

The holes in both upper and lower ends of connecting-rods should be ground to accurate size and surface after heat treating. These were a source of trouble with most American and many European engines.

Three-bearing crankshafts for war service should have main-bearing and crankpin diameters equal at least to one-half of the cylinder bore. The length of all bearings should be greater than their diameter and care should be taken to minimize the leakage of oil from the ends by the omission of all oil grooves and continuous relief at the parting line of the two halves of the bearing.

Lubrication Systems

Pressure lubrication to all main crankshaft, crankpin and camshaft bearings is absolutely essential. Pressure lubrication to piston-pin bearings is not necessary if a floating bushing in the top of the connecting-rod and a floating piston-pin are used.

Better lubrication of fan and auxiliary bearings is necessary. Care must be taken that oil overflowed onto gears or other parts does not rob the lubrication of any bearings. It is better to have the system overflow through a weighted valve, the stem of which acts as a pressure indicator. Pressure gages are absolutely unreliable and useless in this service, except for temporary connection during an engine test.

Oil filters are a constant source of trouble and their capacity is never half enough. The best filter in service has six vertical removable coarse-mesh screens in series in a side pocket bolted on to the lower crankcase. The removal of the pocket permits thorough cleaning and also provides a liberal handhole for washing out the case with a steam and kerosene jet.

No piping connections or loose tubes should be used on the lubrication system. The flange support of the oil pump and other parts should contain all the connections and be provided with a tough gasket. After all drilling is finished, all piping should be made part of the case by pressing large externally ground steel tubes with a stepped fit into long reamed holes.

Oil-level indicating blades should be notched on the edge to show amount of oil in the case and marked with three lines indicating "high," "normal," and "low" oil levels, regardless of quantity.

All brass bearing-shells should be finished with a threaded surface before the bearing metal is applied, in such a way that the points of the thread come within a few thousandths of an inch of the surface of the bearing. Most bearings sent from America have too thick a babbitt coating to conduct the heat properly from the wearing surface. Many of the shells are drilled or punched full of holes before being babbitted.

Fuel Economy and Carburetion

The French have made much progress since the beginning of the war in the development of variable venturi-tube carbureters without spring air-valves or other moving parts. On one type the jet is lowered by the opening of the throttle to prevent backfiring with a lean mixture and the balance restored when the gasoline head in the well is drawn down by the suction of the engine. Much trouble has been caused by the use of small screws in brass castings of carbureters, and even by the breaking off of lugs from the castings.

In the main, the economy of American engines is poor because the mixture has to be kept on the rich side to guard against backfiring. This is made worse in practice by the constant weakening of springs and the sticking of automatic working parts on account of the dusty conditions during convoy driving.

Ignition Systems

Ignition systems need cleaning up in their small details. There is little choice between a magneto system and a well designed single spark generator system. Both give more trouble with condensers than with their main essentials, and both suffer from poor wiring. The development of a wiring system that is completely mounted on a fiber rod or other support, and that can be taken off by undoing a couple of clips, would be a great advantage. The plug connections should press down on top of the plugs in such a way that they can be swung to one side for the removal of a plug. The magneto or distributor connections should come to their proper place without having to trace the wiring. Magneto couplings should only connect one way and should be entirely independent of the means of adjusting the advance.

Water pumps should have more liberal packing glands and should use only ¼ in. square woven packing cut into single rings for a standardized shaft. Pumps should be arranged for repacking without removal.

Good mufflers are as scarce in France as good Germans; much work should be done to produce a stronger and more easily cleaned muffler that is worth putting together the second time. The normal type is useless under service conditions.

GASOLINE SUPPLY SYSTEM

The gasoline system is a very difficult problem. In general the simplest possible tank system is best and two medium-size tanks are better than one large tank with reserve capacity. A tank under the seat is difficult to inspect or repair but anywhere else it involves a troublesome pressure or vacuum system. All such systems have given trouble in service and probably the best plan is to place two separate removable tanks under the seat in such a way that one can be easily removed from each side in case of trouble. The type of tank that has given best satisfaction is pressed in two similar halves with a flanged and lapped joint horizontally around the center. The tank is supported on a wooden runner for the whole length of the flange on one side and on a short wooden support on the other; wooden wedges are driven in to hold down the flanges. To remove the tank it is only necessary to open the side door of the seat, drive out the wedges, disconnect the supply pipe, and draw out the tank on the wooden runner under the flange. A similar method can be used with a round drawn tank by fastening it with bands or supporting it in a tapered hole lined with brake lining at the inner end.

The piping from the two tanks should be independent with a shut-off valve on each end of both pipes. The pipes themselves give trouble. They should be ½ in. diameter and could with advantage be woven on the outside with some material that would prevent crystallization.

Very large filters with settling chambers should be used; they should be supported on the frame halfway between the tank and the carbureter at the lowest point of the system.

A large filler opening should be provided on all tanks for filling and cleaning purposes. This should be as near the center as possible to enable the hand to reach to all parts of the tanks.

Gasoline is handled in France entirely in rectangular 2-gal. cans. These are easily carried in their original sealed form as reserve. After they are emptied the cans are used at the front for handling water in the trenches.

Cooling System

Individual plain and finned tubes are very much in evidence in radiators on account of the ease of repair of

this construction. Large tank-capacity is necessary, especially at the top of the radiator. Flange or union joints are necessary to enable the radiator to be quickly removed without disturbing the hose connections.

Hose connections should be large, because the rubber on being heated swells on the inside and obstructs the passage. There is need to develop a type of hose (without the insertion of a wire spring) that will not collapse on the suction side.

Fans should be large and their speed should not be too high. Fan bearings and belts commonly give trouble. It is worth while arranging a proper mechanical drive to the fan as part of the engine front drive, as it is always a choice between heating and belt trouble with too loose a belt and bearing trouble with too tight a belt. With a mechanically driven fan a spring drive-clutch is absolutely necessary.

Starting and Lighting

Practically all starter trouble is with the overrunning clutches or with the flywheel gearing. The motors themselves and the batteries, when they have received proper attention, have given better service than would be expected.

All lighting should be arranged on the single wire system with interchangeable single-point lamps and with none in series. The tail-lamp should show a light sideways on the ground for inspection from the driver's seat.

Normally 2-cp. bulbs are used in all lamps with an 8-cp. in the searchlight. The lamps are in service only when the trucks are away from the front. In a fog it is necessary to use 8-cp. bulbs in all lamps, as convoy driving is then very difficult.

Spare lamps of both sizes should be installed on a covered panel with blind sockets on the dash. All lamps should be flexibly connected to sockets, on the dash or frame. These should be identical with the lamp sockets, so that they can be used for testing and can be used instead of the lamps in case of accident. It is necessary to install a tail-lamp on each side, both for driving in England and as markers for a standing park of vehicles on the side of the road.

When interchangeable lighting is used the electrical equipment and wiring should be readily removable as the heat of the lamp soon destroys the wiring.

No instrument or dash lamps should be used. When it is necessary to see any dial on the dash it should have white luminous figures on a black background. Only flexible metallic armored conduit should be used.

All fuses should be double ordinary capacity and the circuit should be protected also by a grounded vibrating circuit-breaker.

Widths of Frame

For the sake of operating in narrow places rather than of turning around in a smaller circle it is necessary that steering to an extreme angle be allowed for. This turning circle limits the frame width and it could be best specified by standardizing the width of frame of Class "A" truck as 33 in. and the width of frame of Class "B" truck as 34 in.; these agree with the standard widths of rear spring seats and permit the use of a uniform 26-in. engine arm.

Frame Design Important

Only straight parallel uniform section side rails should be used and these should be of very liberal size, especially in the width of the flanges.

Pressed steel sections are preferable to rolled structural sections as they permit double row riveting of gussets without drilling near the edge of the frame.

In practice it is often necessary to cut out loose rivets and replace them with riveted-over bolts; with rolled sections the tapered flanges do not provide a square seat for the bolt heads.

The width of the frame must be standardized to harmonize with axle seats and engine supports and to allow of the specified turning radius with the specified front-axle tread.

All cross members should have large integral gussets which should be fastened to the side members by a staggered double row of rivets.

Frames should be as low as the clearance over rear axles will allow, because with flat springs it is difficult in any case to make the front-spring brackets short enough. Long spring brackets will not stay riveted to the frame; the rear brackets especially of the front springs gave trouble and they should be as short as possible, even if the shackles have to be in compression.

Open towing-hooks on either the frames or the towing lines give trouble. The frame should be provided with closed towing loops and the towing lines with strong yoke and chain ends.

Frames should be filled with oak blocks under the second cross frame of the body from each end and holding-down bolts should be clamped round the frame at these points. These bolts should only hold the body down, separate means being provided for locating the body in position on the frame.

Accessibility of Steering Gear

There was considerable trouble in removing steering gears from the frame and in removing other units without disturbing the steering gear. The steering gear is located farther out from the center-line of the truck than is usual on account of the wider three-passenger seat. The best position of the steering gear is on top of the frame, supported in a bored-out bracket riveted to the top and outside of the frame with the steering-arm directly outside the frame.

If the stem of the gear is supported in a stamped ball cup in the center of a removable plate on the foot-board the steering gear can be lifted out at any time without dissembling and without disturbing anything else. It is also out of the way of engine arms and allows the engine to be lifted or slid forward for removal. It also caters to straight steering connections. The steering-gear shaft should not be allowed through the frame or anywhere else where it has to be dissembled for its removal or the removal of any other unit, as during quick replacement of a unit in the field it is often impossible to dissemble a damaged or jammed steering gear.

Gearshift Positions

In practice, with the low reductions necessary for service, the four-speed truck is normally started on second gear, which corresponds to the low gear of a three-speed transmission. The low gear and reverse are only used for maneuvering so that it would be an advantage if the control position for both of these speeds were inside the separate latched gate. This would make it possible to rock backward and forward in a tight place in a way not possible when the reverse position only is in the separate latched gate.

DETAIL REQUIREMENTS FOR BODIES

All bodies should be wide enough to cover the rear tires in such a way that the mud will not splash on to the

sides and be carried up under the cover into the body. If the treads of rear tires are standardized the bodies of both Class "A" and "B" models should be the same width. Bodies should be built as low to the ground as possible in order to assist the unloading by hand of heavy ammunition boxes.

The body parts should be strictly interchangeable. If sides are removable they should be fitted with stakes projecting both up and down in order to permit the placing of the side either way up. All of the side pieces should be absolutely interchangeable in any position, either way up.

Tail-gates particularly have been bad in detail. They should be made of hardwood, preferably white ash, not less than 1½ in. thick. The best form of hinge is made by using a piece of 1-in. standard pipe with 3/16 by 1¼-in. strap iron bent round the pipe and extended up both sides of the gates to the top. The two straps are then bolted through, using the wood of the gate for a filler. No forgings are necessary and the strap hinges provide the necessary steel runners on the surface of the gate.

Floor-boards should be uniform and each board should be provided with a steel strap runner on the center line. The boards should be protected with a thin steel U-plate, which should hold down the ends of the steel straps. The U-plates should be riveted on and the board handled as a complete unit. The cutting of trapdoors in the floor is unnecessary, because the transmission and other units have to be examined and cleaned while the truck is loaded. In reserve supply or ammunition columns especially the loads may remain in the stationary or moving trucks for weeks at a time. In normal operation the load is likely to be delivered to the first-line horse transport after dark, the truck then returns to railhead for refilling as soon as possible and probably does not again deliver at the front until after dark the next night. Therefore all trucks should be designed to facilitate repairs and inspection while the body is loaded.

The body covers are a difficult problem. On British trucks they are carried on front, rear angle-iron couches with longitudinal wooden purlins supporting the canvas. This system holds too much water on the top and it is common to see intermediate purlins added by the men themselves. The continuous bent-wood bow on the prairie schooner system appears to be the best. All bows should be interchangeable and the ends should be protected by metal U-plates riveted on. The rear and front flaps of the cover should be independent of the main sheet.

Bodies should be fitted with ample accommodation for the kits of four men and for tools, shovels, crowbar, axe, jack and tow rope.

Painting of Bodies

All trucks at the front are crazy painted, which means that after they are painted a khaki color they are daubed irregularly with various colors to break up the surface and make them less conspicuous.

CLUTCH AND TRANSMISSION PARTS

The clutch should not overhang the engine bearings and its design should not require annular bearings to line up with the scraped-in engine bearings. Its operating mechanism should be supported on its housing and should be much better lubricated than usual. The troubles are mostly in the operating mechanism and in all types are exaggerated with the wear of the clutch surfaces. Except in the details of each particular design there is little to choose between the cone, three-plate and multiple-disk dry types.

I can see an enormous advantage as regards service and quick replacement in a truck comprising an engine unit with a double universal-joint directly behind it, a rear axle with a propeller-shaft and universal-joints directly ahead of it, and a center unit combining all of the clutch, transmission and operating mechanism. I first studied these details in the construction of a German war truck in 1911, but I did not realize their advantage until I had seen actual war service. Since only annular ball or roller bearings are used, there is no difficulty in properly aligning the component parts.

Three-Point Support Favored

The complete unit should be supported on three points for the same reason that the engine should. A number of such trucks have been built from standard component parts, which were intended for the normal type of construction. A double-woven disk universal-joint was used between the engine and the front of the clutch and transmission unit. The unit consisted of a front case and a rear case connected by a flanged tube. The front case contained a standard multiple-disk clutch, the clutch-operating mechanism and the gear-shifting mechanism. The brake lever was also pivoted on this case. The rear case contained nothing but a standard four-speed transmission and the shifting forks. The drive-shaft between the clutch and the transmission was housed in the flanged tube between the two cases. All of the parts used, except the two cases and the connecting flanged tube between them, were standard production of the parts makers. The results have been fully up to expectation and much better than with a truck having a clutch combined with the engine.

A clutch and transmission unit suggests a lubricated clutch with all of the operating parts running in oil. From the great trouble with clutch-operating mechanism I can foresee the revival of the wrapping clutch, properly lubricated and encased.

Clutch-Pedal Movement

The wear of multiple-disk clutch surfaces is much smaller than that of the surfaces of the plate or cone types, but owing to the number of disks the slightest wear produces just as much increase in the clutch-pedal movement as with the other types. The pedal lever soon comes in contact with the floor-boards and in ordinary constructions any readjustment of it affects the clutch brake. Practically the only remedy is to add clutch disks up to the original thickness or to insert a collar behind the thrust bearing of an equal thickness. Some companies have compressed all faced clutch-disks under a heavy hydraulic press before assembling, which to a certain extent lessens the trouble.

Universal-Joints

After carefully studying universal-joint troubles I am convinced that woven-disk universal-joints will supersede the metallic lubricated joints ahead of the transmission and that they can be designed to give equal satisfaction behind the transmission, even with the large gear reduction demanded in war service. I have examined many of the lighter leather joints which gave good satisfaction in London omnibus work but afterward failed in France, but the advantage of not needing lubrication and the actual success of later joints cannot be doubted.

With either type of joint the length of the propeller-shaft and the angularity of the joints should be limited as much as possible by good design. The propeller-shaft weight should be decreased by tubular construction.

In the case of any lubricated type of joint, leather covering should not be depended upon to retain the lubricant, but only to prevent dust and foreign material from accumulating upon moving parts of the joint.

Results with No Differential

Some form of limited differential action is necessary. The truck with a free differential is hopelessly mired whenever one wheel drops into a hole. A standard spiral differential was thoroughly tested, but it was evident that the design was not heavy enough for the severe service.

Many trucks were run without differentials. These gave surprisingly good results and instead of decreasing the tire mileage, as would be expected, the mileage appeared to increase. This could only be attributed to the decreased slip of the wheels on the granite block pavements and in the mud and holes nearer the front. These trucks would pull over almost impossible places and were the best evidence of the need of limited action.

Other trucks were similarly fitted in Canada and used in the construction of camps with similar results. These trucks had a 156-in. wheelbase and I have driven them on asphalt streets heavily loaded without being able to detect the absence of the differential.

DESIGN OF AXLE PARTS

Front axles of the reversed Elliott type are rapidly replacing the Elliott type in new war-truck designs. This is due to the need of lower spring seats and higher steering connections, and to the demand for straight steering-knuckle tie-rods. The ordinary axle is dropped in order to lower its center and give clearance under the engine. The tie-rod is similarly dropped. To do away with the drop it is necessary either to raise the engine or to lower the spring seats. Raising the engine spoils the design by increasing the angularity of the drive and by raising the floor of the truck. It also prevents the use of an internal-drive axle in place of a worm axle; a layout giving absolutely straight-line drive to a worm drive results in an angularity of the drive to an internal-drive axle of all that can be permitted. To remedy this by dropping the axle seats without raising the engine means an axle with at least 3½-in. drop from the center of the wheels to the spring seats. Few Elliott-type axles have this drop and if they have it, the steering-arms are bent considerably so as to make them a proper height for a straight steering reach. The reversed Elliott satisfies these conditions much better.

Improved Brakes Necessary

Brake design must be more liberal and much better in detail. Brakes give probably as much trouble in not properly releasing as from any other cause.

Both the cam or toggle-operated segment and the full wrapping brakes give good service if the details are well worked out. The former, as a rule, has segments too long to permit the best operation, as the ends do not bear in the direction of the applied pressure and decrease rather than increase the braking action. Most of the latter are not well enough supported and centered in the released position to prevent rubbing against the drums with consequent heating and wear.

Brakes must be much better enclosed and protected from the mud and dust. I have seen standing vehicles splashed on exposed brake parts until it was necessary to remove the wheels and thoroughly clean the parts before the vehicle could be operated.

Many trucks and cars have fair service brakes and inadequate emergency brakes. In France it is necessary to be able to slip the wheels with either set of brakes without exertion.

In general the brake levers should be longer and have more movement than is usual, to allow smaller stresses in the rods and especially in the threaded adjustment points. They should be so planned that, without adjustment except for the applied position of the pedal or hand lever, all of the levers and parts will, until the brake band is worn out, be approximately at right angles to the pull when the brake is applied.

TIRES AND WHEELS

The standardization of tire treads is important. The front tires should be the same gage on center lines as the rear tires rather than have the front and rear tires line up on their inner edges, as this makes steering difficult and rubs the inner edge of the front tires. This occurs in the Class "A" United States specifications.

All trucks sent from Canada were fitted with demountable tires on standard S. A. E. rims. This was decided upon before the British had adopted the American pressed-on type with a view to easy replacement in the field. Two makes were used in approximately even quantities. On both makes the locking rings and bolts and nuts were thoroughly galvanized. Most of the tires were carefully shipped with wooden center-struts fitted to prevent distortion of the rims. Ample spare tire parts of all kinds were supplied.

The subsequent use of these tires on the muddy roads in Flanders showed that they were much more difficult of replacement than the pressed-on type which is now standard on all British trucks. After the tires had been in use for some time in the mud they were removed only with the greatest difficulty, and once the rims had become rusted it was often impossible to remove them, even in a tire press. The most effective way was to take out the remnants of the rubber and to jar and expand the rims with a sledge hammer.

The tires of the pressed-on type on the contrary were easily applied and removed in a tire press, which was always to be found at every tire store. Tire presses also were fitted on railway cars, which were always available at railhead points with a stock of tires. As the main function of the motor trucks was to ship material and supplies from these same railhead points this method of replacement was a very simple matter.

Spare wheels with tires applied were always available at more advanced points, but these were necessary in any case to guard against the breakage of wheels and were easily used if there should be an emergency case of tire trouble in the field. Tires were almost universally pressed on with burlap strips. This was at first criticised, but it did not appear to cause any trouble, as with the general muddy condition it probably aided in the quick rusting on of the tire.

The standardization of the pressed-on type of tire on S. A. E. rims cannot be too strongly recommended. I am satisfied that the demountable type will be found wanting in war service in France.

Advantage of Single Tires

It is advisable to limit the number of sizes of tires to as few as possible. It is possible to use 5-in. for front wheels of all trucks, because the smaller trucks are naturally faster moving and the additional speed will easily make the wear even.

In France many of the trucks had 5-in. dual tires on the rear wheels. These developed serious troubles on account of the load often being concentrated on one of the tires

only. On the granite block roads a projecting block on a damaged road would often cut out a large section of one of the tires. On heavily cambered roads the weights would concentrate on the inside tires. I am convinced that the wider-section single tires on rear wheels suffered less damage from these causes than the dual tires. I believe that tires with a slightly convex tread give better service than absolutely flat-tread tires. Many of the tires sent from America to France appeared to be over-cured. In general they were harder and more liable to crumble than the European tires. On the other hand, many of more resilient tires gave trouble near the base and became detached from the steel ring.

Metal Wheels Favored

Cast steel and pressed steel wheels are rapidly replacing wooden wheels. These should be finished on the outside to S. A. E. standard dimensions. The hubs should be standardized so that all makes of ball and roller bearings shall be interchangeable in them. The use of a separate flanged hub makes too heavy a construction. In general the smooth disk is preferable to the open spoke type on account of the muddy road conditions.

SPRING CONSTRUCTION

Springs should be flat under load in both front and rear. Springs with not less than three reverse leaves and with a straight main leaf give the best service because the recoil on bad road surfaces is less. Several springs without spring eyes, pivotal fastenings or shackles have been tried with success and combined half-elliptic and cantilever springs are in use. The development of these makes possible the use of leaves of uniform thickness and length and promises to have a bearing on future production. Springs with a slow period are necessary and are worthy of considerable study.

Avoiding Spring Center-Bolts

Several methods of avoiding bolts through the center of spring plates have been devised. In one an additional spring clamp is used in the center of the spring seat, with a small pressed projection on each leaf. In another the ordinary clamps are used through a plate which goes on top of the spring seat for the purpose of holding the spring leaves assembled. The spring seats are counterbored to accommodate the clamping nuts.

Continuous round clamps over a semicircular saddle block are preferable to those having square corners.

Spring Shackles and Bumpers

The spring shackles at the rear end of the front springs should be in compression to allow of short brackets on account of difficulty in riveting them to the frame.

Although the use of rubber or spring bumpers to limit spring travel is advisable, no bumpers of present construction give satisfaction. Some with much more liberal proportions should be developed.

Lubrication of Spring Pivots

Whether oil or grease is used, the lubrication should be taken care of in the pin itself; projecting oil and grease cups, whether screwed in direct or through elbow fittings, are constantly being broken off or lost. If a lubricating hole is uncovered for a mile the grit will enter and cut the parts regardless of the lubrication method.

Types of Final Drive

There is no objection to a liberally proportioned Hotchkiss drive through flat springs with recoil plates; in fact, this system properly designed has many advantages. However, many Hotchkiss drives gave trouble, as well as many of the drives with radius-rods and torque-arms. With the low gear reductions used in the transmissions the wearing and bearing surfaces in the driving details of any system must be of liberal area. In every case that I investigated I placed the trouble on the details rather than on the system used.

The same thing is true of the various systems of mechanical drive to the wheels. All of the enclosed systems used gave success or failure according to the details of design. The chain drives were for the main part unprotected from mud and sand and so were working at a great disadvantage. A few were enclosed, but these suffered through inaccessibility. Under ordinary conditions the chain-driven vehicles were efficient and easily maintained. The severity of the service and the bad weather conditions have finally ruled against the chain drive in favor of the fully enclosed types. In the newer designs the worm drive, double-reduction gears and internal drive gears have entirely superseded chain drive.

MAINTENANCE METHODS

In the best organized mechanical transport companies a careful mileage record is kept not only of each truck, but of each unit in the truck. This is used as a basis of inspection, cleaning, lubrication and repair. The record systems vary, but are mainly based on semi-daily reading of the hub odometer, checked by a calculated distance according to the service done. For instance, the connecting-rod bearings will be inspected after a definite distance and be taken up if they show the slightest need. All of the units from the engine to the rear axle are washed out on a definite mileage basis. All companies have a proportion of reserve trucks and the ones to be worked on are placed in this reserve.

New trucks are numbered on the frame and on each of the units, as well as on the body, and the service of each unit is separately recorded. Recognized number plates should be provided on the cases of each unit.

The hub odometers used could be much more liberally designed; the means of driving from the axle spindle particularly gives trouble in almost all cases.

Tools and Accessories

In any truck it is an advantage to limit the number of tools necessary for ordinary operation. This is especially true of a truck for war service. Tools should be non-adjustable as far as possible. Several trucks in France are limited to the use of four sizes of bolts and nuts and one gets along with three. To handle four sizes needs but two double ended wrenches. The wrenches have an end socket and two side sockets set 15 deg. apart at each end; the small end of the large wrench fits the spark-plug. Only socket wrenches should be allowed. The smallest threads used should not be less than $\frac{3}{8}$ in. and these should not be used when there is any risk of twisting them off. The strength of a 200-lb. driver has more to do with breakages than the actual strain on a bolt in service. Only the best hand tools should be supplied. The ordinary $3 set of tools in a canvas case is useless. Tools should be standard for the whole service and should be bought in quantity from the tool makers and not with the vehicles.

The same is true of jacks. The average jack is use-

less; in the mud it is hard to maintain the best ratchet type jack. Stout bottle screw jacks in two lengths are the most practical. When a truck is mired it is impossible to use the jack except under the frame. To do this it is necessary to carry short lengths of plank and chains with strong yoke-ends to chain the rear axles to the frame. Each truck must carry a sledge hammer, an axe, a crowbar and a shovel.

First Aid and Relief

A first aid truck and relief trucks accompany all truck convoys. These trucks run the last in the train and stop and help any truck that falls out of the line. If necessary, a relief truck will tow the straggler or take its load so that the first aid truck can work on it. The traffic is arranged so that one class runs on each road and to a great extent in one direction only in order that vehicles pass one another as seldom as possible. The ordinary motor truck route is from railhead toward the front until the roads are too bad and the loads are delivered to the smaller units of the horse transport. The truck then returns to the railhead by another route. After they are reloaded they proceed again toward the front.

Somewhere on the route their rest camp will be situated. This location is chosen in as sheltered a spot as possible and it is moved whenever German guns or airplanes become too friendly. Here the reserve first aid truck, the workshop trucks and the stores trucks carrying supplies and repair parts are left working on the reserve trucks and units. The repairs done here are limited to those requiring two days' work on any one unit. If engine bearings need scraping in slightly and tightening, this would be done, but if parts were broken, the unit would be taken to railhead, shipped to the advanced base and another drawn in its place.

This work has to progress regardless of weather conditions, and all workshop, store and first aid trucks should be provided with a rolled-up canvas shelter on a heavy roller on each side with suitable struts for the support of the roller. These shelters also are used as the headquarters office of the company, in which all of the clerical work incident to ordering parts is done.

It is necessary that each company shall be provided with adequate parts' lists and as far as possible with bound loose-leaf books of photostat reductions of the drawings of the trucks used.

The workshop trucks are fitted with machinery for small emergency repairs, although most of the repairs should be accomplished with standard finished parts. With trucks of European manufacture, the machine shop feature is more necessary than with interchangeable parts of American manufacture.

The machinery is mostly electrically driven and the current derived from the small direct-driven sets is also available for lighting. The store bodies are fitted on each side with steel bins with inclined bottoms for the reception of the small parts.

AMBULANCES AND SPECIAL VEHICLES

Ambulances are for the most part on long-frame, specially built passenger-car chassis. The bodies are 8 ft. long and must not overhang the rear axles more than one-third of their length. To accomplish this, a wheelbase of about 145 in. is necessary. The bodies carry two drivers, an attendant and four stretcher patients or eight sitting patients. With sitting patients, one-third of the weight of the patients and of the other three men is distributed between the two axles; the other two thirds of the weight is balanced directly over the rear axle. This means that a load greater than that due to the weight of eight men and their equipment, or a load of over 1600 lb., is carried directly over the rear axle, this being exclusive of the body weight.

The sizes of ambulance rear axles, springs and tires have had to be increased in order to stand the load. Ambulances are mostly fitted with dual pneumatic rear tires on account of this. Incidentally, the dual rear tires improve the traction about as much as an ordinary locked differential, and ambulances so equipped surprise the average driver by their ability on bad roads.

Bodies for Ambulances

All ambulances are designed with a center aisle and a seat for the attendant on account of the number of serious cases requiring these facilities. The average ambulance is very uncomfortable for sitting cases. The best arrangement is to leave the seat in position for the lower stretchers and to hinge the back upward for the upper stretchers in the opposite manner to the ordinary upper sleeping-car berth. This arrangement provides a comfortable seat for sitting patients and also a pad under each stretcher to take the weight of stretcher patients when the ambulance strikes a bump. The side rails of the ordinary stretcher spring and the canvass sags in an uncomfortable manner without such a support.

Steel runners for the stretchers should be channel shaped on one side only and flat on the other to allow for variation in the width of the stretchers, as the stretcher stays with the patient to his journey's end.

Box or parcel bodies of practically the same type as an ambulance body are used on the same type of chassis and might just as well be interchangeable with it except for the internal fittings. These bodies are used for light service, such as mail, officers' mess-cars or ammunition cars for motorcycle machine-gun batteries. Their loads and speed requirements are about the same as those of an ambulance.

Special officers' bodies, some with sleeping arrangements, are also fitted to these chassis. To my mind they are better suited to the severe service than are standard touring cars. There is also the advantage of fewer types, which is the real slogan the army automotive engineer must maintain.

ADDRESSES AT THE WASHINGTON DINNER

THE final as well as one of the most important events of the Summer Meeting was the dinner held June 26 at the New Willard Hotel. Seven hundred members and guests of the Society were in attendance, every seat in the banquet hall being disposed of. All the speeches were of the highest importance in connection with the prosecution of the war, and are given below in full.

President George W. Dunham was the first speaker and reviewed the part that S. A. E. members will take in this internal-combustion engine war. He introduced Judge W. Benton Crisp as toastmaster.

Judge Crisp proposed the health of the President of the United States and of the rulers of all the allies associated with this country in the carrying on of the war. He explained the need for the immediate development of the aeronautic industry and told of the work that the Society is doing for the Nation in all the automotive fields.

Secretary of War Newton D. Baker was introduced and made a brilliant and schclarly address on the causes of the war. He heartily thanked the Society for its work in connection with aeronautic and motor-truck standardization.

The work being done by the Aircraft Production Board, one of the advisory committees attached to National Council for Defense, was explained by Edward A. Deeds, one of the civilian members of the board.

The last two speakers of the evening were Wing Commander J. W. Seddon of the Royal (British) Naval Air Service and Captain Amaury de la Grange of the French Flying Corps. Commander Seddon took as his text the destruction wrought in England by a recent German airplane raid and showed the results that will be obtained when a large number of American airplanes are brought into action on the fighting line. Captain de la Grange paid a graceful tribute to the courage of the American aviators and told of the prizes that will be gained from the supremacy of the air.

ADDRESS OF PRESIDENT GEORGE W. DUNHAM

IN many ways the Summer meeting of 1917, now drawing to a close, stands out distinctively among all others. It is the first meeting since the amalgamation of the various engineering societies and interests representing practically the entire industry of the internal-combustion engine.

Our country is engaged in a deadly struggle for the maintenance of democracy. We have been called upon for help through a solicitation of the membership, and are not found wanting. Many of our members are already actively engaged in the different branches of the united services, while the rest stand ready to do their share. The Society is maintaining an office at Washington, and many of its members are working with the Council of National Defense. We occupy a peculiar position in relation to this war, because it is a struggle of the internal-combustion engine as evidenced in the automotive devices used.

George W. Dunham

The automobile engineers, who are now amalgamated with the aeronautic, the motor-boat, the tractor, the stationary engine, and the motorcycle engineers, have stood as an example before the world of what could be done in the way of reducing the cost, increasing the output, and simultaneously improving the quality of forms of articles now so well known to us, automobiles and trucks, constituted of a large number of parts and requiring infinite ingenuity and labor in their proper conception and reduction to adequate economic practice in the hands of the public. These men have been real benefactors of the race. They are, by virtue of their experience and capacity, the men who must play a very large part in the Government's aircraft-production program. Their facilities for the manufacture of articles requiring the best machine-shop workmanship stand in a class by themselves, and must be drafted for the purposes of the Government at this time. The Aeronautic Division of the S. A. E. Standards Committee has been hard at work for over a year formulating standards making possible large production of airplanes of the best design and quality. Several of the sessions have been held at the Bureau of Standards, and representatives of the Government have always been in attendance to present its views. The Aeronautic Division is clearly entitled to the full support of the Society and the industry.

The farm tractor presents an entirely different set of problems, which require the deepest study to solve properly many questions relating to the world's food supply. The Tractor Division of the Standards Committee is carrying on broad research work related to the economic and engineering matters involved. Some time ago it made specific recommendations to the Department of Agriculture and the Council of National Defense as to the relationship and necessary action in connection with the

increase of production of small grains and the production and operation of a sufficient number of farm tractors in this country.

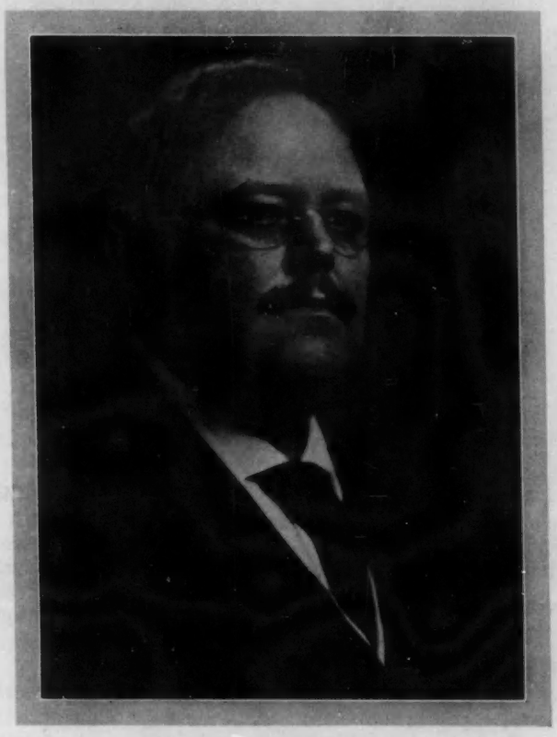
The current military truck specifications formulated by the War Department Motor Transport Board, after much study and conference with several Divisions of the Standards Committee of the Society, constitute a monumental production of national as well as engineering importance.

The nation is looking with confidence to the Army and Navy to conduct its affairs of this war. The S. A. E. is made up of a capable, aggressive, and closely knit body of men who have through a period of years developed the most versatile and necessary power for Army and Navy requirements. The members of the Society are already assisting to the best of their knowledge, but they also stand ready to use their abilities so as best to serve the country of which we are all so justly proud.

ADDRESS OF JUDGE CRISP

SOME years ago it was my privilege to assist in releasing the automobile industry from the shackles of that unholy and unrighteous patent commonly known as the Selden patent, thereby enabling that industry to develop more rapidly during the past eight years than any other industry has in the present decade.

At present I am engaged with a number of patriotic gentlemen in seeking to release the airplane industry from the shackles of the patent which has bound it for the last eight or ten years. I hope that within a few weeks, perhaps in a few days, it will be announced that that industry has been opened up to the world and will be free to the manufacturers of every country.



Judge W. Benton Crisp

The opening of this industry to the world could not take place at a more opportune time. In our present emergency the government, of course, needs every resource at its command, but none more so than the airplane. No other instrument of warfare or transportation can be supplied as expeditiously as that. No other instrument of warfare can be made so effective as that. It can be utilized in almost every branch of the service. If this war is to be won, and won quickly, it is to be won by the use of airplanes, and the quicker we get them in great numbers and put them upon the battle front, the better it will be not only for this country but for all of our allies engaged in this war.

I am reminded that it was in Washington that the airplane industry had its birth. Its father was that distinguished scientist and man of culture, Samuel Pierrepont Langley, who contributed so much of his substance in bringing the new art into being and developing it. It was from him that the Wrights received their first inspiration and a large part of the data that enabled them to make their wonderful experiments at Kitty Hawk.

I can say naught except praise of the Wrights, great aviators that they were, and of Curtiss, great designer, manufacturer and developer of the airplane that he is, but I must declare that the greatest credit belongs to Langley. He wanted nothing for himself; his entire energies were devoted to his art, and the product of his energies was given freely to the world. I wish we could proceed to that little mound now inclosing his remains, and that we could there place upon his tomb the everlasting wreath of fame, which should have encircled his brow during his lifetime.

In our present emergency no subjects are of greater importance, are of more vital interest to the government, than the objects and purposes represented by the Society and the industries of its various members. I trust I may be pardoned for saying to those in authority at Washington and to those who are at the head of the great departments of this government, that no other society or organization can be of greater service to the government, and can be more efficient in that service, than the Society of Automotive Engineers, every member of which stands ready and willing, upon the call of the government, to render any service to it, in its hour of need, that he is capable of performing.

The President, with the great wisdom that he has always displayed, has summoned to his aid as his advisors, and to administer the affairs of the great departments of the government, a number of gentlemen of the highest and best type—men in whom his confidence is ever-abiding, men whose ability has been tried and tested by him, and who have never been found wanting. One of these gentlemen was born in the grand old commonwealth of West Virginia, and pursued his studies at that splendid institution of learning, the Johns Hopkins University. Early in life he became deeply interested in the great social, political and economical questions of this country. Later on he took public office, principally because it gave him an opportunity to study our institutional developments and because it constituted, to use his own language, "a forum from which economic and social questions could be effectively discussed." No other Secretary of War has ever had to deal with such complex, momentous, important and perplexing problems. When history is written his standards and his performances will be found to have measured up to those of his distinguished predecessors.

ADDRESS OF SECRETARY OF WAR BAKER

I HAVE on a number of occasions attempted to address scientific societies, and I have always found myself under embarrassment, because I have no mechanical instinct. Yet at every step in my life I have come to have a deep realization of the indispensable importance in our modern life of the precision and ingenuity of science. Never have I had that lesson brought to my mind so well as at the present moment.

The United States is at war, and it is a twentieth-century war. Men have evolved the processes by which they wage this kind of contest, from the day that the man who threw the first stone and aided his native strength by the use of a weapon until now, through all the various stages of human progress. In the art and science of war men not only are using but are depending upon the latest and highest development of science that human ingenuity and human intelligence have been able to evolve by their most determined efforts.

Hon. Newton D. Baker

This war will be won by the most ingenious, the most subtle and the most scientific people in the world. And when we have finally won that victory it will be written down of us that our men of science, that our men of talent, contrived more subtle and effective agents and engines for our soldiers in the field than our adversary was able to contrive, and therefore that we won.

It is especially interesting to me to find this great body of men meeting here in the national capital, representing, as they do, the most recent advance in mankind's progress toward the capture and utilization of new modes of motion and new forms of force. The internal combustion engine is younger than any of us in its useful development; and yet this war is being waged, so far as its extraordinary aspects are concerned, largely by the use of the internal combustion engine. It used to be that war was waged on a level plain; it is now waged in the sky, with various forms of heavier-than-air machines; it is waged under the surface of the waters with submarines propelled by internal combustion engines. It used to be that men could see the persons they were fighting. That is now no longer true, for the most part, because by indirect artillery fire men shoot over the top of ridges and across valleys at enemies whom they do not see and whose position they locate by means either of aircraft or by intricate devices based entirely upon scientific processes, the use of which was as yet undreamed of before this war began.

There has been taken out of war much of the spectacular aspect to which we were accustomed when we read as children of the battles of our fathers. No longer the cavalry, the eyes of the army, scout over the country and come back to give information to the advance guard of their forces. The captain ordering his men to sweep the field with the bayonet and to make the spectacular charges that characterized ancient warfare is in large part a thing of the past. Now we have over a set of interlocking trenches the grim organization of the ultimate power of two great groups of nations, by processes of attrition seeking to show which is really the stronger, the subtler and the abler, in order that the palm of victory may be awarded to that one.

The use of all these engines and machines is having this curious effect upon the war. We do not know what the outcome of this particular war will be, but in the earliest days, when men fought face to face and hand to hand, two men, for instance, each fighting the other, one was killed. It was a hand-to-hand conflict, in which one or the other was victor and the other vanquished; the contest was not ended until the victor had killed his adversary. And through the earlier days of warfare a loss of forty or fifty per cent in each contest was maintained. As men began to devise weapons with which they fought at greater ranges, larger bodies of men were employed, but the percentages of loss fell off. As war became more scientific, as it used more and more subtle weapons, larger bodies of men were engaged and the gross losses were perhaps larger, but the percentage of loss showed a constant tendency to decrease.

We do not know whether that will be true in this war, but we hope that it will be. We hope that in the end the ultimate loss of human life will have been reduced as compared with the percentages in earlier times. On our own side we trust that those losses will be reduced to a minimum. Every effort that the great nations of the world are now making is directed toward inflicting that sort of damage upon an adversary which will cause him to desist from the conflict with the minimum loss to our own side.

Challenge to the Engineer

The great challenge in this hour of trial of theories and the political foundations of nations, when all the substantial things of earth and the world seem to be seething together in the melting pot, the great challenge to automotive engineers is to develop a better type and to produce a larger quantity of aircraft, so that the great dominance and unquestionable supremacy in that arm will rest with us and we can see where our adversaries cannot see and can protect the lives of our own people by supplying them with accurate information of every military operation. When the great program that has been laid out for the building of aircraft gets under way I believe that automotive engineers, those associated with them, the industries they represent, will all be in hearty accord, and that they will realize that they are as truly winning battles as though they were at the actual front

of the conflict and that the contributions of science are effective both in bringing this great conflict to an end and in minimizing the loss of life and treasure to our fellow citizens.

All of us are enlisted in this great cause, to bring peace back to the earth; not a mere cessation of hostilities, not a mere agreement to quit until we are ready to start again, but a peace based upon such a complete vindication of the principles of liberty and justice that never again within the life of any one now living or perhaps of their grandchildren will any nation ever throw the whole universal civilized world into such slaughter and destruction.

We have been very busy for the last thirty or forty years in this country with our scientific inquiries and our inventions. We have made more wonderful machines than men ever had made before. We have opened up undreamed-of storehouses of natural resources of wealth. We have prospered in our material prosperity and marvelously extended the dominion of human knowledge over the forces of nature. Yet I doubt whether all those triumphs will be worth while, whether the enduring satisfaction of the human race derived from them will justify them, unless they can be drafted, like every other moral force in the world, into this conflict in order to establish upon a firm foundation a lasting and just peace. They must be made to minister to our international composure and peace, just as much as they do to our individual welfare when we are engaged in its actual pursuit.

As men of science and men who are acquainted with the most recent things, men who constitute the advance guard of progress in civilization, we must have first of all in this world a recognition of certain fundamental principles upon which national existence and international peace rest. It will not do for anyone to sit off in a corner and say, "It is well with me." No man lives to himself; no nation any more lives to itself. There was a time in history when a river was a sufficient protection for the continued existence of a nation and when a mountain range was an impassable barrier to the adversary. But that day is past. Our welfare is inseparably associated with the welfare of every other man in the world, and when injustice sets its foot upon the remotest part of the earth the echo of its advancement there is heard in our home. We must establish throughout the world conditions that make for justice. The things that happen in the world now happen instantaneously for all of us. The great scientific resources and powers that we have conquered and brought to earth make us one people, one at least in our interest in the establishment of just conditions among men.

Now that is our primary interest; that is the thing that we are in the world first to establish. We are building for man here on this earth a great temple in which he may live. The foundation stones of that temple are justice among men and peace and right dealing and death to all forms of international self-consciousness and aggression. The old free-booter age among nations, when the possessions of another nation were fair prey to any that were strong enough to take them, without regard to their rights, must forever be closed before we can begin to build the structure of this temple that will improve human and individual rights.

A year or two ago the President of the United States announced—and it was regarded as a very remarkable thing for us to have arrived at a place where the President could announce it—that there had to be formed among the civilized peoples of the earth a league to enforce peace, a league among nations to prevent unjust encroachments upon the rights of others. That league, of course, is to be among the civilized peoples of the earth, and they are relatively few; the burden is on them, however, to establish this rule of justice among the nations. In order that this league may enforce peace it must have at its command all the ingenious devices that its superior civilization can give it in order to make the enforcement of peace easy and effective among the uncivilized peoples of the earth.

Our task therefore is an international task. Our task as a civilized people is to press forward in our scientific inquiries, to improve all those devices that are now contributing to the richness and fullness of life. We must improve the civilization of the civilized parts of the world and resting upon these foundations of justice that we are now struggling to establish, build up both a strong civilization and a beautiful civilization; one so strong that no man or aggregation of men in the world will be bold enough to try to encroach upon its strength, and one so just that if a man went through all the length and breadth of it he could not find even a single individual suffering injustice.

When we accomplish that ideal then perhaps the millennium will have come. But at least that is the ideal we ought always to have before us. The man who works in science and thus contributes to the service of mankind ought always to have the feeling not that he is a mechanic in things of material character alone, but that he is a master builder toward the ultimate perfection of a civilization that has justice as its chief goal.

War of Transportation

This, more than any other war in history, is a war of transportation. Somebody told me not long ago that the English had built in France since their troops have been there more than 5000 miles of railroad behind their lines. Undoubtedly the French have built many thousands of miles of line. Undoubtedly all the combatant powers have been building railroads and increasing the rolling stock. They have been building ships, and they have been making enormous and unprecedented use of motor trucks. If it were not for the internal combustion engine I doubt whether the great armies of the world could be supported in such tremendous masses as are now lined up along those fronts. So that this is a war of transportation.

This government, in entering into this war and in making the preparations to carry forward its share of it, must be supplied with the best means of transportation. Some time ago Colonel Baker, of the War Department, I am told, in cooperation with members of this Society, undertook to prepare specifications for motor trucks, so far as they were used by the War Department. I personally was tremendously proud, when the Mexican situation arose, to find that although our trucks were not made for the service that they were there required to give, they proved reliable for the forces of General Pershing and others that had for a long time to depend upon them.

I hope that the motor-truck program will be pressed forward and that we will have the enthusiastic support of S. A. E. members in that. And in the air program, I trust that when General Squier, Mr. Coffin and their associates reach out into this country and touch any man on the shoulder who either has a tool that will contribute to the making of the airplane, or an engine, or has an idea that will contribute to the perfection of either, he will feel himself by that touch and

that call consecrated to this country's service, until his best has been contributed to the success of our cause.

In this war we have a conflict of principles. On the one side England, which is substantially a democracy, and France, a republic almost as old as our own, the first great republic of the world, and Russia, purifying herself for her share in this conflict by throwing off autocracy and assuming the robes of a democratic form of government, so that those arrayed on our side are wholly representative of democratic principles. This war is really one of democracy against autocracy. It is a war of the rights of peoples against the rights of houses, of potentates, of princes and despots. It is the right of individual freedom expressed here through collective and aggregate action against the suppression of individual freedom. It is for the vindication of the very fundamental principles which in 1776 we declared to be the rock bottom upon which this republic rests. These principles, in some cases by a process of gradual substitution, and in other cases by revolutionary processes, have swept over the world until now they have engirdled the Central Powers of Europe, not any more with armies and cannon, but with principles of eternal right, with the democratic principle gradually spreading the mantle of its protection of individual right, of liberty and happiness for mankind throughout the world.

Because of this great struggle, democracies everywhere are feeling in their veins the same throb that thrills in ours. After it is over, people will realize that democracies are not, as we were once vainly asked to believe, scattered, inefficient and ineffective, but there will be found in them these two great virtues: that in times of peace individual rights and happiness grow and flourish, and are nourished and recognized; and that in times of stress and strain men who live in democracies so love that liberty that by common impulse and common consent they concert their action and coordinate themselves into a compact, irresistible force that tears down all aggression and opposition and clears the way for new paths of progress and of peace.

My chief purpose in coming here was to urge on behalf of my associates in the War Department who are more immediately and directly charged with the mechanical development of the great engines and instruments that are needed in this warfare, the hearty cooperation of the members of this Society and to thank them in their name for what they have done in the past. But I could not help adding, just because they were in my mind, these things I have said about the larger philosophical aspect of the war.

I feel that I, too, am a soldier, and that all here, too, are soldiers, and that our banner is the banner of democracy, and that that is the hope of the future; and that when the history of this great conflict comes to be written by some calm and philosophical historian perhaps not yet born, he will mark the page in his book that records these great events as the time when science and ingenuity and mechanics became the handmaidens of justice and established among men forever and beyond question rules and principles upon which human liberty can safely rest.

ADDRESS OF MR. DEEDS

IT is with a great deal of hesitancy that I get up here. Mr. Coffin is away attending to some other duties, and I know how glad all of us would be to hear from him. He has probably had more to do with the growth of this organization than has any other man. He also is more full of this subject than any other man, and what he would say would really be worth while. I am relieved somewhat, however. Just now a message came from Mr. Coffin, which I want to read. It is from Altoona, Pa., and was written on the train.

Edward A. Deeds

"Members of the Society of Automotive Engineers: In June, a year ago, the Automotive Engineering idea was first suggested. It is indicative of the energy and initiative of the American engineer that the Society of Automotive Engineers has been for six months an accomplished fact. No better move could have been made to meet the national emergency needs of this war. Every interest represented within the ranks of this organization is now of vital service to the country. Trucks, motor boats, aircraft and automobiles must all play their part in this great struggle. Every member of this Society has become a real cog in the ponderous mechanism that has been set in motion that the world may be made safe for all nations. The work of the Automotive Engineers touches the business of war at every angle, but one phase of its activity is just now of the most vital importance. Absolute dominance of the air has come to be acknowledged as a prerequisite to the success of the Allied armies in the field. Early superiority in air service will spell victory. Inferiority will certainly bring defeat. The coming year's work of this engineering body will decide the permanent air supremacy, and the end of the war will be in plain sight. The old world looks to America for an engineering miracle. The navy of the air must carry the Stars and Stripes into Germany. Every day's delay will cost us lives of thousands. We have not a moment's time we dare lose."

I want to say just a word about the Aircraft Production Board, which was organized May 16, and is a little over five weeks old. This is an advisory board appointed by the Council of National Defense. It is composed of six members: Mr. Coffin, as chairman; Mr. Waldon; Mr. Montgomery, of Montgomery, Tyler & Clothier, the bankers; and myself, as civilian members. We sit with General Squier of the Signal Corps and Admiral Taylor of the Navy.

As Mr. Waldon expresses it, our policy is to mesh into existing machinery that we find at Washington. We are not attempting to create any new institutions or any new channels through which work can be done, but as civilians we are cooperating with existing machinery, because there is plenty of machinery here to do this work.

We, as civilians, often sit back and find fault because the Army has not whipped Germany already and the Navy has not solved the submarine problem. It is very easy to sit idly by and find fault. But I want to say this from my own experience here: The staff of our Army and our Navy are made up of the finest type of men that this country produces. O that I could pick out a dozen men that I have met here and take them back into the Middle West and start industries! Their ability, their vision and foresight, the preparation that these men have made, have been an inspiration to me and will be an inspiration to every civilian who comes here. We have little use for the man who sits idly by and criticises these men. There is one thing that this body can do. As its members go back home, speak a good word for the army and navy officials in Washington who are undertaking to do this tremendous task that has been put before them.

I hope that our board may be the means of helping establish greater confidence between the governmental machinery and the industry of this country. If there is one thing that this war is going to do more than another it will be to bring government and business closer together. When the war is over our board wants to slip back home and leave no new machinery created but a little broader organization for doing the things in the regular way. If by example we can get other committees in Washington to take that same attitude we will bring about a condition that will be of permanent benefit.

I want to outline some work that has been done—not entirely by our board, and I do not want anyone to think that our board alone is doing all these things. Our board has been permitted to be of assistance in some small way here and there by bringing about some very creditable things.

Eight cadet schools have been established in different universities and are giving cadets an eight weeks' course. They are taught the scientific things that they need to know; they are taught something of military tactics, so when they make an observation they can report accurately. They are taught wireless in a small way, they are taught something of aviation and the engine. Every Monday morning twenty-five of the finest young men this country produces are starting these courses at each of the eight universities.

Four large aviation schools are under construction at the present time. These fields are situated so that it will be possible for a squadron to be moved from the East to the West, say to the border, through the air, traveling from field to field. It will be an inspiring thing some day, when a squadron is told, "It is time to go West," to see one hundred or more machines start on their western course to the next field. We will see all of this within a short time.

At Dayton, Ohio, there is a tract of 2500 acres, four square miles, upon which over 3000 men are working, removing trees, houses, fences, traction lines, and constructing buildings. A line of hangars a mile and a half long will overlook this magnificent field. It was inspiring to me to stand upon the hill and look down over this field and see in it a little old hangar where the Wright brothers did their original work. At a single glance one can see almost the entire progress of this new industry—the humble birthplace of the airplane in striking contrast with the largest and most modern flying field in existence. This view embraces all the romance of American inventive genius and industrial achievement. It is a wonderful inspiration.

The primary training machines have been standardized. Just two types will be used for the primary training. The program calls for 2000 of these military training machines to be furnished between now and the first of January. We are confident that those machines will be available at the different schools by the first of the year. There will be a shortage of machines, perhaps, for the first ninety days, before we can get all the fields in operation, but on July 15 actual training work on the new fields will be started.

There is another program, a larger one, yet to come, that of building advanced training and combat machines. That is something on which we must lose no time. We must, however, wait until we get proper information from the front. One hundred of the best mechanics in this country are now abroad, being placed in the engine factories on the other side. With these men went ten men with the best brains and experience that this country affords, from the Army, the Navy, and from civil life. It will not be long before we will have the latest information, samples and models, so that we can intelligently begin the advanced program.

Methods of Developing Engines

We have another important matter under consideration, and that is the matter of engines. We must first develop the types of engine now in production in this country. Again, we will get from abroad the best foreign engines, and have them duplicated in American factories. That will take time, but we must not fail to do this. The third method is the development of a standard "All-America" engine, such as is under way at the Bureau of Standards.

Germany, with her characteristic practicability, has few types of engines and few types of planes. If there has been one mistake that our allies have made it has been that they have tried to develop too many kinds of engines and planes. We will profit by the experience of others. As can readily be appreciated, it is ill-advised to discuss publicly engine design. It can, however, be stated with assurance that the number of kinds of engines will be reduced to the minimum so that quantity production will be possible.

The question of plane design is a little more difficult. That is moving so rapidly, the demands are changing so continually, that we are not up to date on the latest fighting and pursuit machines. We cannot intelligently attack that problem here until we can get samples of planes from the other side. New designs of planes to fit our new engines and to meet new conditions will be developed from the ground up in this country.

Congress is soon to be asked for a very large appropriation for the army and navy programs. We undoubtedly will get its whole-hearted support, and an appropriation will be made without delay. But as S. A. E. members we must realize that such an appropriation will bring with it a responsibility such as was never placed upon the Society. I know we can meet it, but it must be done openly, frankly, and unselfishly.

The first duty of our board and of those responsible will be to place orders with the existing aircraft plants to the very limit of their capacity. They have had their struggling experiences, and should receive every consideration and be given everything that they can do.

The second duty will be to place orders so as to use facilities made idle by the war. Those facilities will very largely be furnished by the industries represented by S. A. E. members.

There will be a third duty—the creation of new sources. That will be the last thing inaugurated.

As soon as this larger program is announced everyone will want to build airplanes. Most of the large number that expect to be considered will have to be turned away. Probably one way in which the civilian members of the board can help is to have the courage to tell those men they will not be needed.

We have time to work with only those industries that are well organized, well equipped and capable of doing this particularly responsible work. We must put into it the very best production processes that this country has, regardless of criticism born of selfishness.

We must work on a different foundation, of course, than they have on the other side. There the proportion of machine work is small; the proportion of hand work large. Since our great grandfathers came we have always been short of labor in this country, and that has forced us into doing everything by machine work just as far as possible. We will have to carry on this work by quantity-production methods, even though it is a difficult matter.

Support from Automotive Engineers

We are relying upon the automotive engineers; we feel that behind us is their cooperation and support. We have only one thing to do; we must be over there next spring with enough aircraft to support our friends on the other side. I wish every member of the Society could have the opportunity to speak, as we have, with men direct from the front. They are deadly in earnest. They are deadly in need of the best that this country can afford, and I know that we will rise to the situation.

Whatever effort it takes, whatever sacrifice required from this or any other body of men, in spite of whatever criticisms, adversity and discouragement, when the great trial comes next summer we must rise up triumphant head and shoulders above all obstacles, selfish attitudes and petty views, and reach out across the Atlantic with engines in one hand and airplanes in the other, with quantities abundant and quality of the highest to give to our own boys at the front and our valiant Allies the supremacy of the air. Then will we have made our greatest contribution to the war. We will do what will be an everlasting credit to this country and to every man in in any way connected with the work.

ADDRESS OF COMMANDER SEDDON

THE thing that is in my heart to say at this moment more than anything else is to acknowledge publicly, with great gratitude, the hospitality that I have received in this country at all turns from the moment I arrived until now.

One thing that has not been emphasized by the other speakers is the enormous value of these aircraft that are to be produced in this country. Here I have a clipping from one of the Washington newspapers:

"German airships to the number of about sixteen raided southeast England on Friday evening. Seventy-six persons were killed; one hundred and seventy-four were injured."

There were seventeen airplanes; they were not airships at all. This happened only the latter part of May of this year. Seventeen airplanes killed and injured two hundred and fifty people in one little short raid lasting just a few minutes. Now multiply that number of airplanes by six; the result is a hundred, roughly, and the casualties would have been fifteen hundred. Multiply that by a hundred more, and we have ten thousand airplanes, the number it is proposed shall be produced in this country, and the casualties are one hundred and fifty thousand in the one short raid. It means a million in two days—two or three days. I do not pretend that I think it is right or justifiable or a thing that should be aimed at, that we should go into Germany and kill their people. I only just brought that point out to show the enormous damage that airplanes can really do. I am certain that if this country puts into the air ten thousand bombing machines that we can wipe out in a month the Essen District and all the munition districts of Germany.

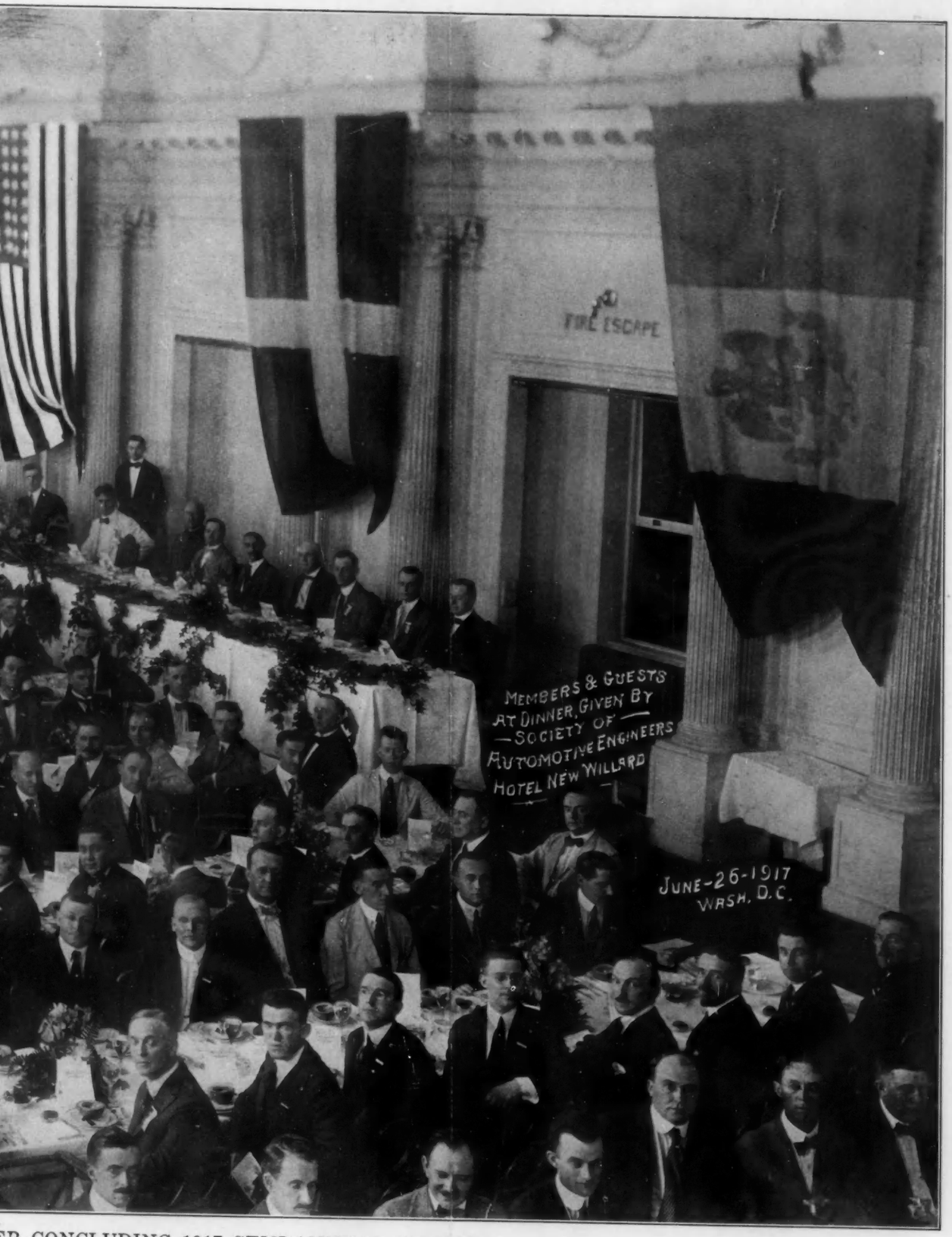
Wing Com. J. W. Seddon

I feel sure that if we do not want to go as far as that that we can wipe out every bridge across the Rhine and destroy every railroad and every railroad station from the German front to the Rhine and can force the evacuation of the Germans across the Rhine.

When the production of wooden and steel ships is under way here what does it mean? The second that happens and we know that they will be finished on such and such a date, we can start being less stingy with the tonnage we have got. Every day saved allows us to release tonnage and get on with the war more rapidly and press the Germans more hardly than we have been doing.

SEVEN HUNDRED MEMBERS AND GUESTS OF THE SOC

NDRED MEMBERS AND GUESTS OF THE SOCIETY AT DINNER CON



ER CONCLUDING 1917 SEMI-ANNUAL MEETING

ADDRESS OF CAPTAIN DE LA GRANGE

AT this time when Americans are preparing to make the greatest effort in aviation that has been made so far by any country, I would like to state why I have such confidence in the undertaking, and what great results one has a right to expect from it.

I know that in a country where aviation, as a military arm, has been ignored until now, it seems inconceivable to certain people that such formidable amounts of money have been asked to carry out the program planned. I am not surprised that some people have honestly asked themselves if it would not be a mistake to expend so great a part of the industrial and military effort of the United States in aviation.

Work for Engineers

It is the engineers, because they have a better knowledge of the situation than anyone else, who will have to say again and again that no sacrifice will be in vain to secure the mastery of the air. They themselves must be absolutely convinced of this, so that they in turn may convince others.

Capt. Amaury de la Grange

This war has been full of surprises. At first the Germans took the initiative, using methods which were convenient for them and suited their temperament, but during the short period when the Germans were compelled to fall back to the Marne, the war was directed by the Allies. Since then, however, the Germans, aided by their efficient methods—fruit of long years' labor—have given the war a defensive character.

This is the reason why none of our offensive moves so far has been completely successful. Whenever the two armies have met in the open the Allies have had the upper hand, but they have been unable to pursue the advantage. for, sooner or later, they were checked by that formidable array of all the arms that modern science has invented.

Fortunately there are two domains in which, if they truly wish, the Allies can reign supreme—the sea and the air. I will not talk of the naval campaign. That is not my specialty. But in all that concerns aerial warfare I am thoroughly convinced that we must work with supreme energy, and that there the United States can play a great part. There the enemy can do nothing to bar our way.

The Battle in the Air

The enemy may prefer to fight on land with mine and shell, burrowing into the ground, rather than struggle in the open, in the good French way, facing each other. In the air, at least, they must fight man to man, or acknowledge themselves defeated. The air belongs to every one, or rather to him who knows how to conquer it with a high hand. There traps do not exist, nor hidden machine guns, nor other obstacles that warp the conditions of the fight. In the sky, two men, armed alike, fight like knights of old in their tournaments. The bravest and the quickest wins, and when he has won, the sky, German as well as French, is his.

Realize the beauty of this struggle, in which all is beautiful, even death. Is any death more beautiful and clean than that of the aviator struck down in loyal combat? The French love the risk and the danger. They play the game well, but they hate treachery. It is the same with the American. When our pilots and their brave English comrades appeal to young America, they know that it is filled with courage and high ideals.

War in the Skies

Those who give themselves up to the skies of France in 1918 will take part in the great battle, the prize of which will be the supremacy of the air. If we lose, our military operations will be hindered, and our towns, whose sons have given their lives to defend them, will be constant prey to the destruction wrought by German aviators.

If we win, the field will be cleared for our enterprises. Our armies will regain complete liberty of movement, while the German army will be deprived of its most precious source of information. Moreover, it will give us a chance to push the war into enemy territory. Our bombing squadrons will harass reserve forces continually and attack all the important strategic points behind the lines, and nowhere will the Germans feel secure.

Our Future in the Air

America will come to know the difficulties of this plan, but they will not hinder her. The work has already begun, and before long Americans will teach the enemy the valor of their pilots and the excellence of their machinery. Germany does not believe that America will ever be a redoubtable enemy. Just as she was mistaken in 1914 when she talked of the "little English army," so now she is miscalculating the little American aviation. Our allies, the English, showed them that they were much mistaken. The Americans will do the same. Some years ago the Kaiser proclaimed that the future of Germany was on the sea. America can proclaim now that her future in this war is in the air.

STANDARDIZATION AT THE SEMI-ANNUAL MEETING

REPORTS of Divisions were considered at a meeting of the Standards Committee held June 25 at the Bureau of Standards, and were presented to the Society at the Business Session held the next day at the Bureau. These reports, except that of the Research Division, are given below in their final form as approved by the Society. It should be remembered, however, that before being officially adopted they must be submitted to the mail vote of the Members. The ballot covering this is being prepared and will be sent out in a short time.

An abstract of the discussion is given immediately after the report to which it relates, that at the Standards Committee meeting following immediately the report and preceding the discussion at the meeting of the Society.

As was to be expected, a large number of important standards were presented by the Aeronautic Division, which has been working almost day and night on account of the pressing needs of the aeronautic industry. The dimensions for airplane bolts and nuts, which are specially important, are based on a considerable amount of testing done by the Division in order to determine just what sizes should be adopted in view of the high-grade material to be used.

The following standards proposed by the Aeronautic Division were approved at the meeting of the Society for submission to mail vote of the Members: Stick control, loops for hard wires, galvanized non-flexible cable-ends, splices for flexible cable-ends, thimbles for wire-ends, turnbuckles, marking of fuel, lubrication and air pipe-lines, engine-support and spark-plug dimensions, use of existing standards for aeronautic work, elimination of gage numbers, basic system of measurements, shackles, clip-ends, shackle pins, airplane rod-end pin, airplane bolts with plain hex heads, airplane bolts with ball hex head, airplane castle hex nuts, airplane nuts with ball hex and ball castle hex head, and magneto-base dimensions.

The report submitted by the Division was accepted with minor changes. The proposed nomenclature of column control was referred back to the Nomenclature Division for consideration. There was considerable discussion of the methods of marking pipe lines, but this was finally approved. The dimensions for magneto-shaft taper were referred back to the Division, inasmuch as it was said that they would require a bearing not obtainable in this country.

The report of the Ball and Roller Bearing Division as approved by the Standards Committee contained dimensions for flat-face thrust ball-bearings and for self-aligning thrust ball-bearings in the metric sizes.

It was thought by the Division, however, that these dimensions should be reconsidered in view of the fact that the metric bearings are used considerably abroad and it was not possible to check up the sizes with the foreign practice. At the meeting of the Society, they were therefore referred back to the Division.

The following subjects presented by the Division were approved by the Society for submission to mail vote of the Members: Flat-face thrust ball-bearings in light and medium series, self-aligning thrust ball-bearings in light and medium series, all of these being in the inch dimensions; also approved were dimensions for steering-knuckle thrust ball-bearings in the metric sizes.

The recommendations made by the Chain Division relating to pitch and width of silent chains were accepted by the Standards Committee at its May meeting. These subjects were also approved by the Society for submission to mail vote of the Members.

A progress report of the Data Sheet Division relating to the classification of the S. A. E. Handbook was accepted. The Division proposes to issue index sheets for the two volumes of the Handbook. In the near future the data now contained in Vol. I of the Handbook will be classified under a number of subject headings. For instance, powerplant, clutch and transmission, and final drive sections have been proposed. Index sheets will then be prepared and all the data listed under appropriate sections. These index sheets will be sent to all the members of the Society.

The dimensions for the generator flange, starting motor flange and ignition distributor mounting as approved at the May meeting of the Standards Committee were accepted by the Society for submission to mail vote of the Members. There was considerable discussion of the generator flange, it being said that separate standards should be recommended for use with chain and gear-driven apparatus.

The report of the Engine Division, providing for poppet-valve dimensions for valves ranging from 1 to 3 in. diameter, was accepted and the dimensions will now be submitted to the mail vote of the Members.

The Lighting Division submitted a terminology for automobile lighting and also made a number of recommendations relating to focusing devices and to the mounting of head-lamps. The recommendations relating to illumination passed by the Society at the January, 1916, meeting were revised. The report of this Division was accepted for submission to the mail vote of the Members.

The Marine Division submitted a report approving the use for marine work of a number of existing standards. This report was accepted for submission to the mail vote of the Members.

The Miscellaneous Division presented revised standards for yoke and rod ends and for rod-end pins so as to include $\frac{5}{8}$ and $\frac{3}{4}$-in. sizes. Limits of the bore are now given for these parts. The recommendations were accepted by the Society for submission to mail vote of the Members.

The report of the Research Division on a complete car performance test was accepted at the May meeting of the Standards Committee and was also approved by the Society for submission to mail vote of the Members. It was voted to express the thanks of the Society to the Research Division for its work. (This report will be found on page 141 of the May BULLETIN.)

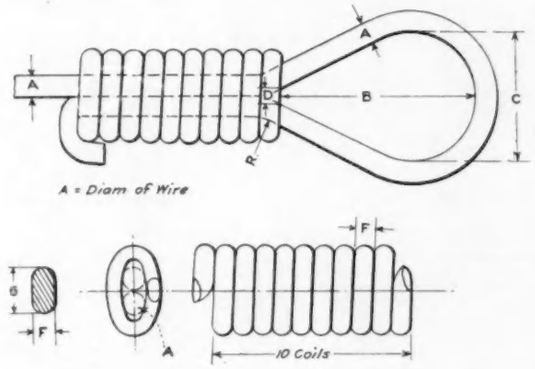
Recommendations made by the Starting Battery Division relating to battery terminal posts and starting battery compartments were accepted by the Society for submission to mail vote of the Members. There was considerable discussion as to the recommendation for the location of the battery compartment. It was voted to eliminate the provision from the report that the compartment was to be located entirely under the front floorboards and that no parts, including cover or fastenings, should project above the chassis frame.

The Tire and Rim Division presented carrying capacities and inflation pressures for pneumatic tires; these were accepted for submission to the Members.

The first report of the Tractor Division was made at the Washington Standards Committee meeting. This covered a number of important recommendations relating to farm tractors of fifteen drawbar horsepower or less. The following tractor subjects were approved at the meeting of the Society for submission to the mail vote of the Members: Drawbar and belt-power rating of tractors, belt speed, height of drawbar, use of S. A. E. standard magneto dimensions, and diameter of magneto drive-shaft.

REPORT OF AERONAUTIC DIVISION

THE following method of fastening ends of hard wires is recommended for standardization. This is the present British standard, consisting of an oval thimble of wire, through which the hard wire is slipped, bent in a loop, inserted again and the end bent over against the ferrule. The whole is then soldered.



LOOPS

Size of Wire A	Large Loop 0.128	Small Loop 0.128	0.102	0.081	0.064
B	9/16	7/16	13/32	13/32	13/32
C	2 3/64	1 7/64	9/32	1 7/64	1 7/64
D	5/64	1/16	1/32	1/32	1/32
R	1 5/64	9/64	9/64	9/64	9/64

FERRULES

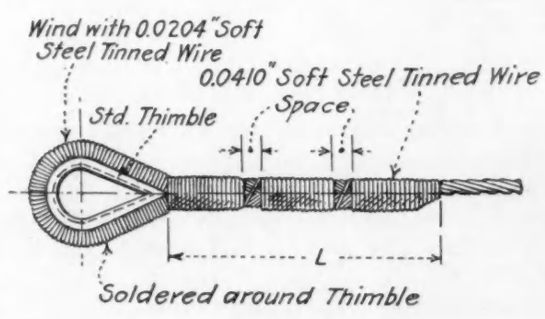
E	0.114	0.114	0.091	0.072	0.057

GAGES

F	0.130	0.130	0.104	0.083	0.066
G	0.260	0.260	0.208	0.166	0.132

Galvanized Non-flexible Cable-Ends

The splices for galvanized non-flexible cable-ends as shown are recommended for standardization. The total length of the splice is indicated by *L*. Soft steel wire of 0.041-in. diameter is to be used for wrapping the splice and for the loop. Two spaces are to be left between convolutions of the wrapping wire, the width of the spaces being indicated in the table, which also gives the sizes and strength.



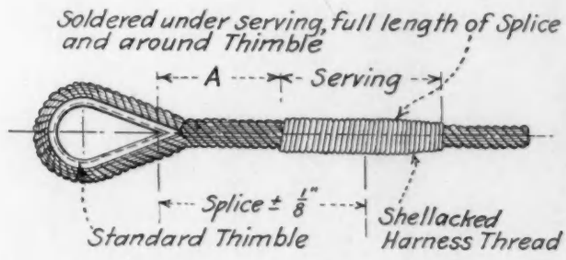
Diameter of Cable, Inches	Number of Strands	No. Wires per Strand	L	Space	Wind	Full Strength of Cable, Lb.
1/16	1	19	1 1/2	1/8	1	500
3/32	1	19	2	1/8	1 1/4	1100
1/8	1	19	2 1/2	1/8	1 1/2	2100
5/32	1	19	2 3/4	1/8	2	3200
3/16	1	19	3	3/16	2 1/4	4600
7/32	1	19	3 1/2	3/16	2 1/4	6100
1/4	1	19	4	1/4	2 1/2	8000

NOTE: Solder without drawing temper of wire. Loop portion served with 0.0204 in. soft steel tinned wire before thimble is inserted.

Splices for Flexible Cable-Ends

Flexible cable splices as shown are proposed for standardization.

The length of splice from pointed end of opening in the thimble is represented by "splice plus or minus 1/8 in." The end of the splice is wrapped with a "serving" of shellacked harness thread. Dimension *A* represents the distance from the end of the opening in the thimble to the end of the "serving."

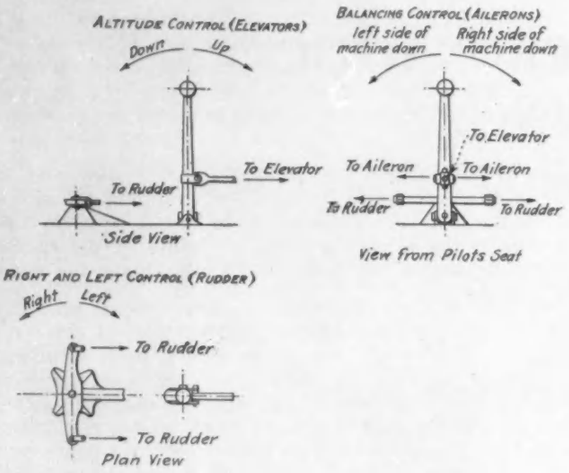


Diameter of Cable, Inches	Number of Strands	No. Wires per Strand	Length of Splice	Length of Serving	A	Full Strength of Cable, Lb.
3/32	7	14	1 1/4	1	1/8	800
1/8	7	19	1 1/2	1	1/8	2000
5/32	7	19	1 3/4	1 1/4	1/8	2800
3/16	7	19	1 7/8	1 3/4	3/16	4200
7/32	7	19	2 1/8	1 3/4	3/16	5600

NOTE: Solder full length of splice without drawing temper of wire. Number of tucks: Three over core buried four under.

Stick Control

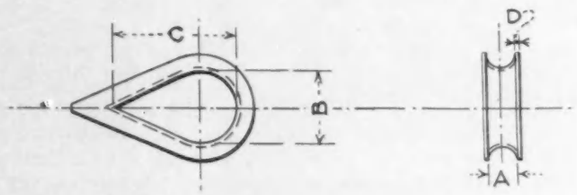
The following diagram illustrates the general arrangement and movements of the type of control generally used



for airplanes of the lighter and faster types. It is not intended to standardize the exact arrangement or connections, but rather the directions of the movements required to produce given results.

Thimbles for Wire Ends

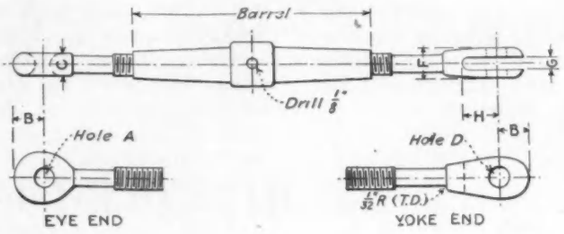
Thimbles as shown in sizes indicated in table are submitted for standardization.



Size of Cable		Thickness of Thimble A	Width of Eye B	Length of Eye C	Thickness of Metal D
1/16	0.062	0.09	0.35	0.70	0.032
3/32	0.094	0.09	0.35	0.70	0.032
1/8	0.125	0.13	0.35	0.70	0.032
5/32	0.156	0.17	0.40	0.80	0.032
3/16	0.187	0.21	0.50	1.00	0.032
7/32	0.219	0.24	0.60	1.20	0.032
1/4	0.250	0.25	0.70	1.40	0.032
9/32	0.281	0.30	0.80	1.60	0.032
5/16	0.312	0.33	0.90	1.80	0.040
3/8	0.375	0.39	1.00	2.00	0.040

Turnbuckles

The turnbuckles shown are recommended for standardization. The dimensions given are for short and long turnbuckles, each length having either two eye-ends or one eye-end and one yoke-end.



Nos.	Strength in Pounds	Eye Ends, Inches			Yoke Ends, Inches				
		A	B	C	D	B	F	G	H
1	500	5/32	9/32	1/4	3/16	9/32	3/16	5/64	3/8
2	1,000	5/32	9/32	1/4	3/16	9/32	3/16	5/64	3/8
3	1,500	3/16	11/32	5/16	3/16	11/32	1/4	5/64	3/8
4	2,000	13/64	11/32	5/16	3/16	11/32	5/16	7/64	7/16
5	2,500	13/64	13/32	7/32	1/4	13/32	11/32	7/64	7/16
6	3,000	13/64	13/32	7/32	1/4	13/32	11/32	7/64	1/2
7	3,500	15/64	7/16	1/4	1/4	7/16	5/16	15/64	1/2
8	4,000	15/64	7/16	1/4	9/32	7/16	7/16	13/64	9/16
9	4,500	21/64	7/16	9/32	9/32	7/16	1/2	15/64	9/16
10	5,000	21/64	15/32	9/32	9/32	15/32	9/16	17/64	9/16
11	6,000	23/64	15/32	5/16	5/16	15/32	9/16	17/64	9/16
12	7,000	23/64	15/32	5/16	5/16	15/32	5/8	17/64	5/8
13	8,000	25/64	1/2	11/32	5/16	1/2	5/8	21/64	11/16
14	9,000	25/64	1/2	11/32	3/8	1/2	11/16	21/64	11/16
15	10,000	29/64	9/16	3/8	3/8	9/16	11/16	23/64	11/16

Type of turnbuckle	Short	Long
Length of barrel	2 in.	4 in.
Made in numbers	1 to 7 incl.	1 to 15 incl.
Length between centers of eyes with:		
Threads flush with ends of barrel	4 in.	8 in.
Ends extended a maximum	4 3/16	8 3/16
Ends extended a minimum	3 1/4	5 1/2

With two eye ends, thread one left hand and the other right hand.
With one eye end and one yoke end, thread eye end left hand.

Marking of Pipe Lines

It is proposed to mark fuel pipe lines with red bands 1/2 in. wide, one near each end and intermediate bands not more than 24 in. apart.

It is proposed to mark lubrication pipe lines with white bands 1/2 in. wide, one near each end and intermediate bands not more than 24 in. apart.

It is proposed to mark air pipe lines with blue bands 1/2 in. wide, one near each end and intermediate bands not more than 24 in. apart.

Engine Supports

The Division recommends the following dimensions (in inches) for standard engine supports:

Distance between timbers	12	14	16
Width of bed timbers	2	2 1/4	2 1/2
Distance between centers of bolts	14	16 1/4	18 1/2

Spark-Plug Dimensions

The following dimensions for spark-plugs are recommended:

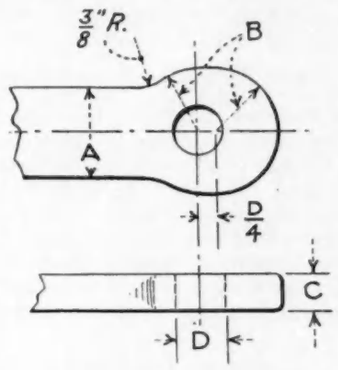
Thread: 18 mm. 1 1/2-mm. pitch.

Form of thread: international standard (same as U. S. standard only with one-half as much truncation at root of thread).

Gasket shoulder to end of shell: 5/8 in.

Clip End Dimensions

The following dimensions for clip ends are recommended for standardization. The dimension *A*, the width



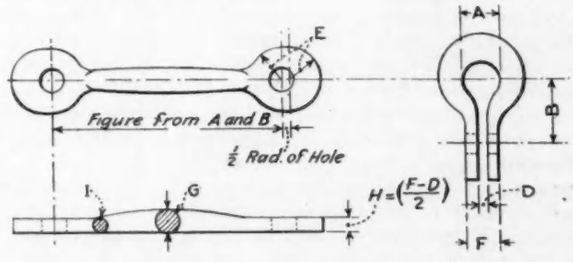
CLIP ENDS

TURNBUCKLE		A	B	C	D
Number	Strength, Lb.				
1	500	.....	1/4	5/16	5/16
2	1,000	.....	1/4	5/16	5/16
3	1,500	.....	1/4	5/16	5/16
4	2,000	.....	5/16	3/32	5/16
5	2,500	.....	5/16	3/32	1/4
6	3,000	.....	3/8	3/32	1/4
7	3,500	.....	5/16	5/16	1/4
8	4,000	.....	3/8	5/16	9/32
9	4,500	.....	3/8	5/16	9/32
10	5,000	.....	3/8	1/4	9/32
11	6,000	.....	3/8	1/4	5/16
12	7,000	.....	7/16	1/4	5/16
13	8,000	.....	7/16	5/16	5/16
14	9,000	.....	1 13/32	5/16	3/8
15	10,000	.....	1 13/32	5/16	3/8

of the arm, is determined by the material to which the clip end is welded.

Shackle Dimensions

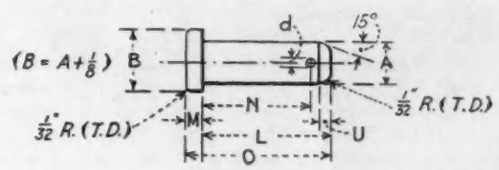
Shackle dimensions shown in the following table are recommended for standardization. Shackle is formed from steel forging.



TURNBUCKLE		Width of Clip Lug D	Hole Size C	Radius E	Diameter A	Lgth. B	Diameter G	Diameter I	Diameter F
Number	Strength, Lb.								
1	500	5/64	5/16	1/4	1/4	9/16	5/16	5/11	5/16
2	1000	5/64	5/16	1/4	1/4	9/16	5/16	5/32	5/16
3	1500	5/64	5/16	1/4	1/4	9/16	5/16	5/32	1/4
4	2000	7/64	5/16	1/4	1/4	9/16	5/16	5/32	5/16
5	2500	7/64	1/4	5/16	5/16	5/8	1/4	5/16	1 1/32
6	3000	7/64	1/4	5/16	5/16	5/8	1/4	5/16	1 1/32
7	3500	1 9/64	1/4	5/16	5/16	5/8	1/4	5/16	5/16
8	4000	1 9/64	9/32	1 1/32	3/8	1 1/16	3/8	9/32	5/16
9	4500	1 9/64	9/32	1 1/11	3/8	1 1/16	3/8	9/32	1/2
10	5000	1 9/64	9/32	1 1/32	3/8	1 1/16	3/8	9/32	9/16
11	6000	1 9/64	5/16	3/8	7/16	3/4	7/16	5/16	9/16
12	7000	1 9/64	5/16	3/8	7/16	3/4	7/16	5/16	5/8
13	8000	2 1/64	5/16	3/8	7/16	3/4	7/16	5/16	5/8

Airplane Rod-End Pins

The dimensions for airplane rod-end pins given in the table are recommended for standardization.



d = Edges chamfered not to exceed 0.01 in. T. D. = Tooling dimension.

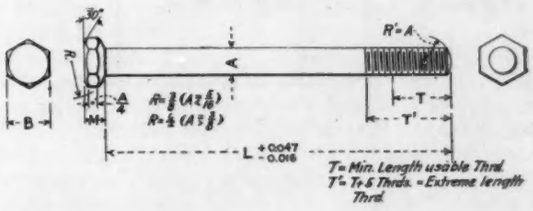
Size A	1/8	5/32*	3/16	7/32*	1/4	9/32	5/16	3/8	7/16*	1/2*
Limits A	−.002 −.004	−.002 −.004	−.002 −.004	−.002 −.004	−.002 −.004	−.002 −.004	−.002 −.004	−.002 −.004	−.002 −.004	−.004 −.007
B	1/4	9/32	5/16	1 1/32	3/8	1 3/32	7/16	1/2	9/16	5/8
M	3/64	3/64	3/64	3/64	1/16	1/16	1/16	1/16	3/32	3/32
L-N	3/32	3/32	3/32	3/32	3/64	3/64	3/64	3/64	3/64	3/64
U	3/64	3/64	3/64	3/64	1/16	1/16	1/16	3/64	3/64	5/64
d	50	50	48	48	48	48	36	36	36	36
Cotter	1/16	1/16	1/16	1/16	1/16	1/16	3/32	3/32	3/32	3/32
Length L										

*Future sizes

Airplane Bolts and Nuts

The dimensions of the following bolts and nuts are recommended for standardization.

AIRPLANE BOLTS
BALL HEXAGON HEAD

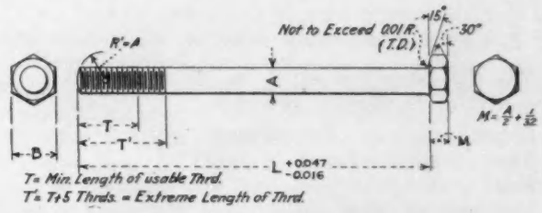


All threads U. S. F. R = 3/8, [A = > 5/16] R = 1/2, [A = > 3/8]

Size—A	No. 8*	No. 10*	No. 12*	1/4*	5/16	3/8	7/16	1/2*	9/16*	5/8*
Th'ds per inch	32	32	32	28	24	24	20	20	18	18
Limits—A	.160	.186	.212	.246	.308	.371	.433	.496		
	.164	.190	.216	.250	.312	.375	.437	.500		
Head diam.—B	5/16	3/8	3/8	7/16	1/2	9/16	1 11/16	3/4		
Head h't—M	1 5/64	1 5/64	1 5/64	1 5/64	1/4	5/16	2 3/64	3/8		

*Future sizes.

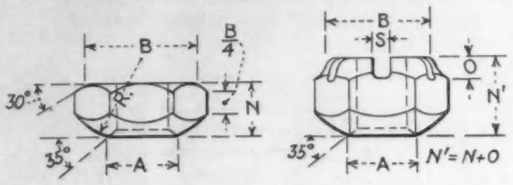
AIRPLANE BOLTS
PLAIN HEXAGON HEAD



All threads U. S. F. $M = \frac{A}{2} + \frac{1}{32}$ T. D. = Tooling dimensions.

Size—A	No. 8	No. 10	No. 12	1/4	5/16	3/8	7/16	1/2
Threads per inch	32	32	32	28	24	24	20	20
Limits—A	.160	.186	.212	.246	.308	.371	.433	.496
	.164	.190	.216	.250	.312	.375	.437	.500
Hd. diam.—B	5/16	3/8	3/8	7/16	1/2	9/16	1 11/16	3/4
Hd. height—M	7/64	1/8	9/64	5/32	9/16	11/32	1/4	9/32

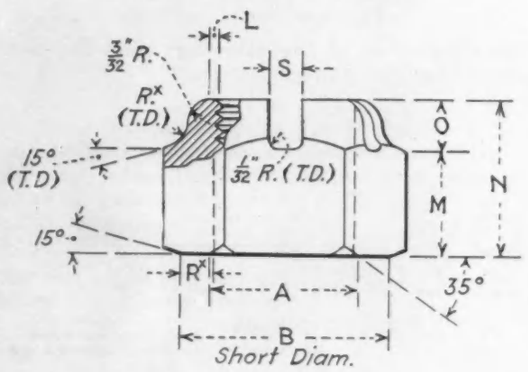
AIRPLANE HEXAGON NUTS
BALL HEXAGON AND BALL CASTLE



All threads U. S. F. N'=N+O.

A	B	N	R	A	B	N'	S	O
No. 8	3/8	1 1/64	3/16	No. 8	3/8	1/4	5/64	5/64
No. 10	3/8	1 1/64	3/16	No. 10	3/8	1/4	5/64	5/64
No. 12	7/16	1 1/64	3/16	No. 12	7/16	1 7/64	5/64	3/32
1/4	7/16	1 3/64	3/16	1/4	7/16	1 9/64	5/64	3/32
9/16	1/2	1/4	3/16	9/16	1/2	1 11/32	5/64	3/32
5/8	9/16	5/16	1/4	5/8	9/16	7/16	1/8	1/8
7/16	1 1/16	2 3/64	1/4	7/16	1 1/16	2 1/64	1/8	1/8
1/2	3/4	3/8	1/4	1/2	3/4	9/16	1/8	5/16

AIRPLANE CASTLE HEXAGON NUTS



All threads U. S. F. O=Also depth of slot. T. D.=Tooling dimension.

A	B	N	S	O	M	L	R
No. 8 32	3/8	1 3/64	5/64	5/64	9/32	1/64	3/32
No. 10 32	3/8	1/4	5/64	5/64	1 1/64	1/64	3/32
No. 12 32	7/16	1 7/64	5/64	3/32	1 1/64	1/32	3/32
1/4 28	7/16	9/32	5/64	3/32	5/16	1/32	3/32
9/16 24	1/2	2 1/64	5/64	3/32	1 5/64	1/32	3/32
5/8 24	9/16	1 5/32	1/8	1/8	9/32	1/32	3/32
7/16 20	1 1/16	2 3/64	1/8	1/8	2 1/64	3/64	1/8
1/2 20	3/4	5/16	1/8	5/16	3/8	3/64	1/8

Use of Existing Standards for Aeronautic Work

The following list of S. A. E. Standards is recommended for aeronautic practice:

Screws and bolts (for engines).
Steel specifications.
Heat treatments.
Ball bearing sizes.
Test-specimens.
Throttle levers.
Magneto dimensions.
Cotter pin sizes.

Gaging of Sheet Metal, Rods, Wires, Cables and Tubes

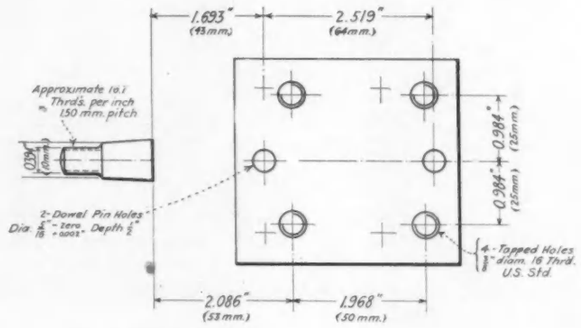
Sheet metal is to be specified by thickness in decimal fractions of an inch. Rods and solid wires are to be specified by diameter in decimal fractions of an inch. Tubes are to be specified by outside diameter in inches and fractions and thickness of wall in decimal fractions of an inch. Cables are to be specified by outside diameter in inches or fractions and the number of wires to a strand and number of strands to a cable.

Basic System of Measurement

In view of the fact that the Army and Navy Departments are not both in favor of adopting the metric system, and further in view of the necessity of arriving at standards that will mean the least possible delay in the production of airplane parts, this Division recommends definitely that the English system of measurements be used except in isolated cases such as spark-plug threads, when the metric system is desirable in order to effect interchangeability with some well established standard.

Magneto Dimensions

The dimensions as shown in the following drawing are recommended for standardization for eight and twelve-cylinder engines only.


1.693" (43mm.)
2.519" (64mm.)
Approximate 16 Thrds. per inch = 1.50 mm. pitch
0.984" (25mm.)
0.984" (25mm.)
2- Dowel Pin Holes Dia. 3/16" +.0002" -zero. Depth 1/2"
4- Tapped Holes diam. 18 Thrd. U.S. Std.
2.086" (53mm.)
1.968" (50mm.)

DISCUSSION OF AERONAUTIC DIVISION REPORT

Controls

C. M. MANLY:—One of the most important things the Division has taken up has been the matter of control for the machine. In the handling of the airplane it is important that the methods of operation of the controls be standardized as far as possible. At the Cleveland meeting of the Committee a report was made covering this matter of the controls, but the Navy Department questions the name (Dep) that we used for the column control. It was suggested that inasmuch as Mr. Deperdussin had nothing to do with the origination of that control, but that it had merely been originated in his factory, it would be well to drop his name. We have simply changed it to be Column Control. Inasmuch as the name has been changed it was considered best to put the matter before the Committee again.

(On motion, duly seconded, it was voted to approve this portion of the report.)

Marking Pipe Lines

C. M. MANLY:—We present for consideration the matter of marking fuel pipe lines, oil pipe lines and air pipe lines. The main feature is that bands of paint of different colors are used in order to show what the pipe is supposed to carry.

W. H. PALMER:—It is suggested that there should be a marking of the pipes in different colors to distinguish

a certain pipe. If there is any such practice, even in some other engineering field, it would seem to be well to have this conform. We are accustomed, for example, to paint the terminal posts in colors to indicate polarity.

JOSEPH HUSSON:—The Navy Department uses a color scheme in all submarines and battleships. There is no place where there are more pipes than in a submarine, and it would be well to follow the same practice. Many of the large manufacturing plants in the country use the same system.

C. B. KING:—The Navy has used green to indicate salt water, red for fresh and white for steam.

(On motion, duly seconded, it was voted to approve this portion of the report, the word "lubrication" being substituted for "oil.")

Elimination of Gage Numbers

C. M. MANLY:—The recommendation relating to gage numbers is put up for the action of the Committee.

(On motion, duly seconded, it was voted to approve this portion of the report.)

Basic System of Measurements

C. M. MANLY:—The next thing to be presented is the "Basic System of Measurements." We called a special meeting of aeronautic manufacturers and members of the Division, and after considering the matter thoroughly the metric measurements seemed to be favored. After we looked into the thing a little more we found that its use would tend to slow up production. If we used metric dimensions for gear centers and had whole numbers in it, we would have to have metric gear cutters and metric reamers. We therefore decided that any consideration of the metric system had better wait till after the war is over.

Loops for Hard Wire

The recommendation for sizes of loops for hard wire is not based on arm-chair theory, but is a result of many years' development. The practice in this country and in foreign countries has been to use various means of fastening these wires, including small thimbles or ferrules made of pieces of tubing. When there was trouble with the tube slipping they used sheet metal, wound around very much the same as the wire is except that it is a continuous sheet, and then it was soldered, and various troubles came from that. This loop method was finally developed and brought to the attention of the Curtiss Company through the British, who demanded it on all their machines. It is used entirely on the other side and has been found very satisfactory. The practice we recommend is the use of ferrules made from wire as shown.

There has been some objection on the part of some of the British to soldering, but in this country all of the departments require that the loops be soldered. The liability of the mesh rusting through before it is used up is not great.

The loops shown are the sizes found to be best adapted to the work required. The solder should be used after the loop is completed without drawing the temper of the wire. It is important that the loop is not soldered in a flame or put in a bath and left there any length of time to draw the temper. Otherwise the strength of the wire will be greatly decreased.

Dimensions are also given for a gage to be used in making up ferrules, to make sure that there will be no trouble on the floor in assembling the parts.

(On motion, duly seconded, it was voted to approve this portion of the report.)

Thimbles for Wire Ends

C. M. MANLY:—The thimbles for wire ends are the ones that have been found to be thoroughly satisfactory in actual service. The subject is presented for action.

A MEMBER:—I would like to ask if there is any tendency to use wire with stream-line cross-section.

C. M. MANLY:—They are using a great deal of it in Europe. At the same time, if we hold back merely because something else is approaching, we will handicap the work greatly. We hope to present a report very soon on the whole matter of stream-line wires.

We have not attempted to cover everything. We do not want to hold back the whole work of aeronautic standardization while we settle some small point. That is the spirit at which we are going at this work. We feel that it is so important to make as much progress as possible, as rapidly as possible, that we are trying to eliminate all matters of controversy and straighten them out later. At the same time everything that is not a matter of controversy we are trying to bring to the fore as rapidly as possible.

(On motion, duly seconded, it was voted to approve this portion of the report.)

Turnbuckles

The turnbuckles proposed are substantially the ones that have been used now for about two years in the British machines built in this country by the Curtiss Company. Some changes have been made in order to rationalize the small differences that have been mere drafting room details.

We have not attempted to specify the diameter of the shank or the pitch of the thread or the exact detailed dimensions of the barrel, because those are things that do not affect, for the moment at any rate, the question of interchangeability as regards substituting one manufacturer's product for another. We want to have the turnbuckles of standard length between the eyes and to have standardized mounts and adjustments so that in case the product of one manufacturer was not to be had we could substitute the product of another without any inconvenience. We have also recommended the standardization of parts that affect the fittings that these turnbuckles are attached to, such as the wire which is usually put in at one end, the other end of the turnbuckle being fastened to a clip of some kind.

G. E. GODDARD:—I see there are no limits given on those holes, as we have on the rod-ends. I believe that there should be some clearance allowed to facilitate assembly.

C. M. MANLY:—We will present that as soon as possible, but the matter of limits was another one about which there was considerable discussion, and rather than hold up the entire work until the last detail should be settled, we decided to present it in its present form.

CHAIRMAN UTZ:—This Division is very much pressed for time, and the standardizing of school machines is right in question now, and such things as the limits of all those parts will have to take their turn.

(On motion, duly seconded, it was voted to approve this portion of the report.)

Shackles

C. M. MANLY:—We next have the shackles, which are made up as a small drop forging by two methods; one is to bend and then drill, and the other is to drill and

then bend. The question of which method is best followed is a secondary matter. It is largely a question of tooling. The thickness of the yoke end has been made to correspond as nearly as possible with the dimensions on the turnbuckle, in order to make as few as possible the different lengths of rod-end pins, which are used with both the turnbuckle and the shackle.

(On motion, duly seconded, it was voted to approve this portion of the report.)

Clip Ends

C. M. MANLY:—The clip ends are usually parts of the fitting, which may vary a great deal. We felt it best to propose these standards along with those for turnbuckles, shackles and such parts. They all go together, the shackles being frequently used to fasten on to the clip.

(On motion, duly seconded, it was voted to approve this part of the report.)

Shackle Pins

C. M. MANLY:—The main feature of the rod-end pins is that we have made them as nearly like the present S. A. E. standard pins as seemed wise. It has been found in practice that thinner heads are just as effective, so that the heads have been left thinner than the standard pins. The drill-hole sizes have been made as large as it seemed wise to make them, so far as the strength of material of the pins was concerned. It is desirable to use a large size of drill on account of the machine-shop difficulties. The end of the pin, instead of being just a straight bevel, as in the S. A. E. pin, is given the same degree of bevel and then just a slight rounding on the corners; this is marked TD 1/32, which is a tooling dimension. We did not want to have purchasers carry little fillet gages in their pockets and inspect the corners and fillets, so we call them tooling dimensions; they are not inspection dimensions. This also applies to the corner on the head; the 1/32-in. radius is a tooling dimension.

In all the recommendations relating to rod-end pins and to bolts and nuts, we have had the invaluable assistance of E. H. Ehrman and of F. G. Diffin. We have actually had representatives of two manufacturers working with the Division, so the matter has been pretty thoroughly threshed out as regards what we want and what is commercial to make.

(On motion, duly seconded, it was voted to approve this portion of the report.)

Airplane Bolts

C. M. MANLY:—These bolts are not proposed for engines, but for use on airplanes. In order to determine the proper thickness of heads we made a number of tests at the Curtiss plant. We started with bolts having very thin heads, so that we were sure they would shear off, and tested them by pulling them from a fixture and then kept putting in bolts with thicker heads until we found the minimum thickness of head that would always cause failure.

The first bolts tested were made of material not heat-treated. This was 3½ per cent nickel steel, 15-25 carbon, which actually contained 0.16 per cent carbon, 0.58 per cent manganese, with phosphorus and sulphur specified below 0.05, and actually about 0.02 per cent. We found that the head of the untreated bolts had to be about 10 per cent thicker than that of the heat-treated bolt; the heat treatment strengthens the head more than it does the body, because the cold rolling produces more resistance as regards tension than as regards shear parallel to the fibers. We then tested a number of heat-treated bolts, but knowing the likelihood of variation in heat treatment we thought it best not to make the thickness of the head such that the head might pull off, even in the untreated bolt.

We therefore recommend that the heads of heat-treated bolts be ½ D plus 1/32 in., the extra 1/32 covering very small bolts.

Instead of making the underside of the head perfectly square, we have shown it as chamfered, from the corner of the hex to the circle that encloses the short diameter, the angle being 15 deg. That is to remove the burr that results from the machining of this nickel steel.

Then on the top of the head there is a chamfer of 30 deg. instead of 45 deg., because with small bolts with thin heads it is important to have enough material left for a wrench hold. At the same time we want to do some chamfering in order that the bolt be better finished than would be the case if it had a square head. The end of the bolt has been simply rounded off to a radius equal to the diameter.

We have not specified the length of thread. The bolt makers state that three threads is the minimum difference between the threads that show and the usable threads. We have therefore specified the difference between the usable thread and the amount of thread that shows as five threads, in order to cover the variations that are bound to come in the regular production.

We considered the adoption of the A. S. M. E. standard thread for the numbered sizes, but it is important that a large number of these training airplanes be gotten under way at once. We have not attempted therefore to reach an ideal at first in connection with standardization work, but have pushed the things that have already been used and were being used now with good results, leaving such questions as the advisability of having A. S. M. E. pitches for later consideration. What we recommend are now being used extensively in the airplane business.

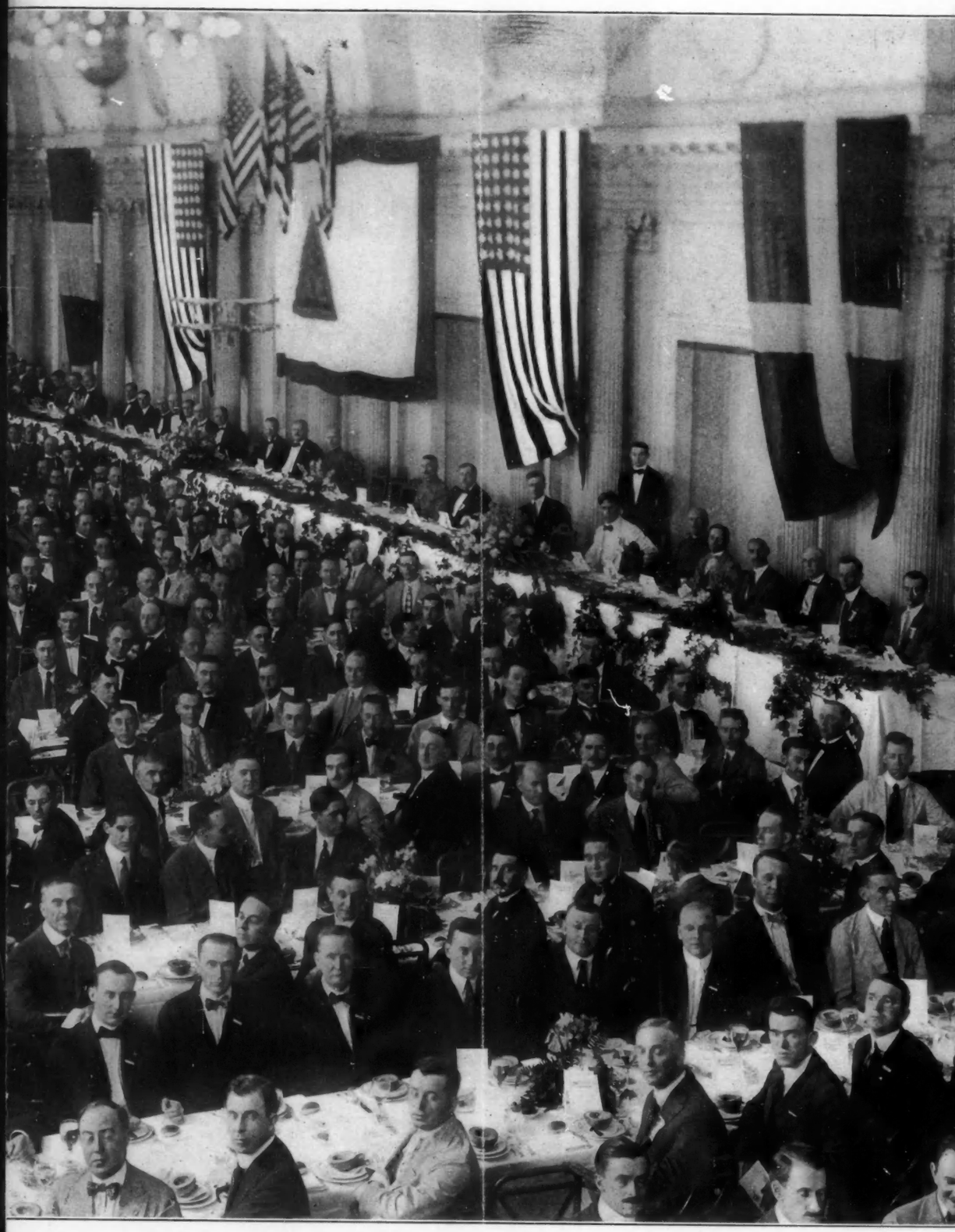
A. T. BROWN:—Would it not be possible to make arrangements to have only a few sizes of heads for bolts, so that only a small number of open-end wrenches would be required to fit them.

C. M. MANLY:—Very few airplanes carry a kit of tools around with them, but they must carry the bolts. We therefore have not thought it best to burden the machine, which has several hundred bolts, with a great deal of extra weight in order to decrease possibly by twenty-five per cent the number of wrenches that might be used.

C. S. CRAWFORD:—Do I understand that from the ¼-in. size the bolts are practically the S. A. E. standard?

C. M. MANLY:—We have followed the S. A. E. except for two sizes; one is the ¼ and the other is the 7/16-in. bolt. For the latter the diameter across the flats is 11/16 in., which is the old A. L. A. M. standard instead of ⅝ in., which is the present S. A. E. standard. That was based on actual results of test, especially when so much aluminum and wood are used, and the bearing pressure on the bolt becomes of considerable importance. The suggestion was made that the bolts should not have hexagon heads, but that they should be round and have screwdriver slots in them. We have had in mind the fact that we are after quick production; that it is seldom necessary to grip the head of the bolt with a strong hold while the nut is being screwed up. We are hoping to get nuts that are pretty well fitted. The ball head hex bolts are substantially the same as the others, except that the head has been chosen with reference to giving suitable bearing area and not digging into the fitting too deeply.

SEVEN HUNDRED MEMBERS AND GUESTS OF THE SO



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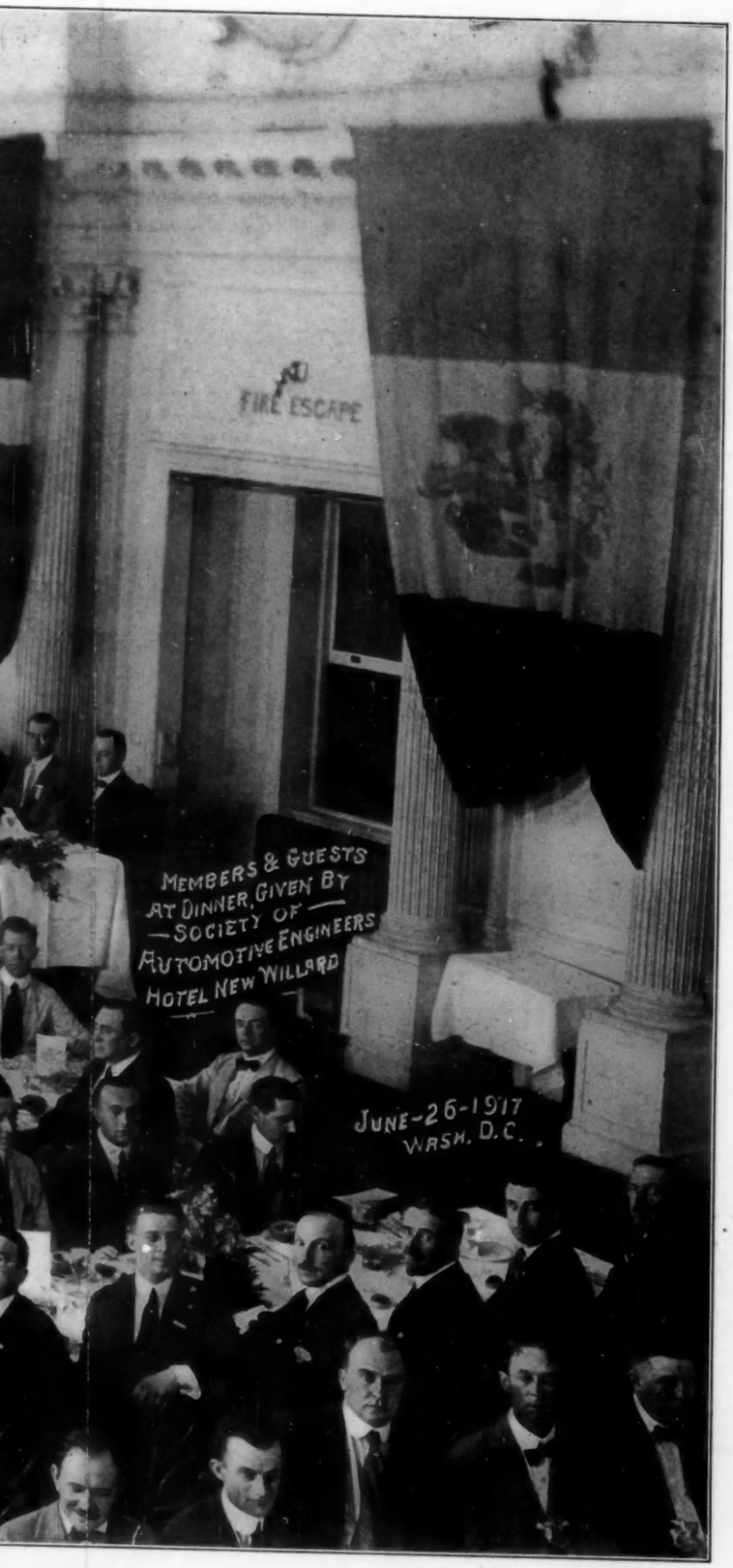

FIRE ESCAPE
MEMBERS & GUESTS
AT DINNER, GIVEN BY
—SOCIETY OF—
AUTOMOTIVE ENGINEERS
HOTEL NEW WILLARD
JUNE-26-1917
WASH, D.C.

L MEETING

(On motion, duly seconded, it was voted to approve this portion of the report.

Castellated Nuts

C. M. MANLY:—We tested a number of nuts, starting with nuts that were so thin that the threads stripped, carrying the tests up to a point where the nut, without taking into account the castellated portion, was stronger than the bolt and would not strip. We tried this both with the plain, that is, not heat-treated nut, made of ordinary cold-rolled stock, and then later tried nuts made of cyanided material. It was best to have such nuts on the soft side so there would be no danger, even if the cyaniding had not been carried out thoroughly. But I think those nuts will be satisfactory, even though they are not cyanided. Of course the cyaniding is wanted in many places.

The right nuts for airplane parts must be slightly thicker than for ordinary bolts, on account of the frequency with which they are taken off. To a large extent the stripping of the threads depends on the fit of the nut. We have suggested these standards not for the best fitted nuts, but for what would be called a good average fit, without being tight or without being more than about two to two and one-half-thousandths loose between the thread on the bolt and the thread on the nut.

We have also made tests, which we intend to make on large bolt-heads also, on nuts that were inclined at an angle of about three degrees, so as not to get into trouble in case the machined boss was not square with the bolt; these nuts were safe under those conditions. With this castellation the nut is turned off on a reverse curve. There are two reasons for that. In the first place, this is a stronger nut than the S. A. E. nut with the straight relief; and in the second place, inasmuch as the aeronautic nuts will be of a different height from the S. A. E., we thought it just as well to have a different shape; in fact, to make the nuts readily distinguishable. Both of those considerations led us to adopt the shape which is being used a good deal in aeronautic construction now.

(On motion, duly seconded, it was voted to approve this portion of the report.)

Ball Nuts

C. M. MANLY:—At present we are not using any of the plain ball hex nuts. Practically all the bolts on airplanes are locked with cotter pins, but there may be cases when such a bolt as this is needed, with a clip and castle nut on top. This nut is made strong enough so that it will not strip and is substantially the same as the plain castle nut, except that the ball seat has been rounded off to the same radius as the ball head on the bolt.

(On motion, duly seconded, it was voted to approve this portion of the report.)

Magneto Base

C. M. MANLY:—The next thing is the base for the airplane magnetos. It has been reported that the present height, 45 mm., was not sufficient to allow the use of suitable magnetos for eight and twelve-cylinder engines. This recommendation is similar to the French standard; the dimensions have been indicated as inches with the metric equivalents, but are taken really from the French standard.

(On motion, duly seconded, it was voted to accept this portion of the report for submission to the Society.)

DISCUSSION AT SOCIETY MEETING

JOHN G. UTZ:—The report of the Aeronautic Division has been accepted by the Standards Committee, but it seems that the dimensions of the magneto base have been questioned. In the first place, the two dowels on the base should have been 8 mm. in diameter. The taper on the driving end of the magneto has also been questioned.

A. D. T. LIBBY:—The question as to what the dimensions of this taper should be has arisen in the Aircraft Production Board. A 40-mm. bearing is called for, whereas the present magneto standard is a 35-mm. bearing. There is some question now as to the delivery of the larger bearings in quantities. I therefore move that the matter be left open until the engineers of the Aircraft Board can pass on it.

W. C. ALLEN:—The name "Column Control" is not the proper one to use, because it is not really a column control. I suggest the use of the original name, Dep control, by which it is known throughout Europe and also here, among aviators.

A MEMBER:—I would like to suggest, as a compromise, if we have the stick control, why not call the other the wheel control?

N. B. POPE:—We have a Nomenclature Division whose duty it is to attend to these matters as they are brought up, and it seems to me that the meeting as a whole is not perhaps qualified to pass on the subject.

W. C. ALLEN:—I move that the name of this control be referred to the Nomenclature Division.

(It was voted to refer the name of column control to the Nomenclature Division.)

O. C. ROHDE:—Why is a 1-in. standard hex recommended for airplane spark-plugs? That is not the standard in any of the spark-plug parts now used. We cannot use the S. A. E. standard of 7/8 in. unless we make the plug out of round stock, but we could make it 15/16-in. hex, which is now the size of most plugs in this country. It seems that we should adopt some standard that is already in use, rather than fix on entirely new usage.

J. G. UTZ:—As I recollect it, the dimensions were worked out to correspond with the foreign millimeter standards, on account of the possibility of many of our planes going abroad. The plug is one of the parts that would have to be interchanged and replaced; American plugs would be used on foreign engines, and foreign plugs on our engines.

O. C. ROHDE:—I believe the foreign standard is 1.053 in., and that would not make it interchangeable.

A. C. WOODBURY:—An investigation made by the S. A. E. office on the foreign spark-plug hexagons showed that no standard sizes were established, only that several companies were using the 26-mm. hex.

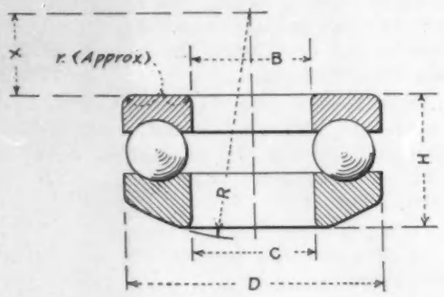
J. G. UTZ:—If the 1-in. hex is not satisfactory, it would be ill advised to refer the whole plug standard back. It will then not be possible to bring it before the Society again before next January, and we hope to have 30,000 or 40,000 airplanes in use by that time. It would be better to refer back only the dimensions across the hex.

(It was voted to accept the report of the Aeronautical Division as revised, excluding the recommendation on column-control, taper dimensions for magneto and spark-plug hex dimension, for submission to the mail vote of the Society.)

REPORT OF BALL AND ROLLER BEARINGS DIVISION

(As accepted for submission to mail vote)

PROPOSED metric dimensions for steering-knuckle type thrust ball bearings are shown in Table I. These and the following tables of inch sizes were worked up with more reference to establishing rational lists of sizes than to the present practice of any manufacturers. Still they are satisfactory to almost all of the makers of thrust ball bearings.



Flat-Face Thrust Ball Bearings—Light and Medium Series—Inch Dimensions

Proposed inch dimensions for light and medium series flat-face thrust ball-bearings are shown in Tables II and III respectively.

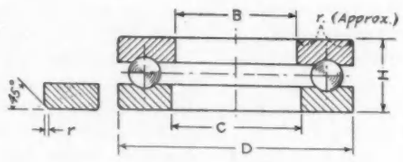


TABLE I—PROPOSED STANDARD METRIC SIZES FOR THRUST BALL BEARINGS—STEERING-KNUCKLE TYPE

Bearing Number	B		D		H		C		X		R		r		Bearing Number
	Mm.	In.	Mm.	In.	Mm.	In.	Mm.	In	Mm.	In.	Mm.	In.	Mm.	In.	
TS- 8	8	0.3150	22	0.87	14	0.55	8.5	0.33	0.00	0.000	15	0.59		0.04	TS- 8
TS-12	12	0.4724	32	1.26	15.5	0.61	12.5	0.49	11.00	0.433	28	1.10	1	0.04	TS-12
TS-17	17	0.6693	37	1.46	19	0.75	18	0.71	8.50	0.335	30	1.18	1	0.04	TS-17
TS-22	22	0.8661	46	1.81	24	0.95	23	0.91	11.00	0.433	38	1.50	1	0.04	TS-22
TS-24	24	0.9449	54	2.13	26	1.02	25	0.98	21.00	0.827	50	1.97	1	0.04	TS-24
TS-26	26	1.0236	60	2.36	31	1.22	27	1.06	21.00	0.827	55	2.17	1	0.04	TS-26
TS-30	30	1.1811	66	2.60	34	1.34	31	1.22	23.00	0.906	60	2.36	1	0.04	TS-30

TABLE II—PROPOSED STANDARD INCH SIZES FOR THRUST BALL BEARINGS FLAT-FACE TYPE—LIGHT SERIES

Bearing Number	B	D	H	C	Ball Dia. d	r
TP-L- ½	½	1 5/16	7/16	9/16	5/16	1/32
TP-L- 9/16	9/16	1 3/8	1 1/32	5/16	5/16	1/32
TP-L- ¾	¾	1 9/16	½	1 3/16	5/16	1/32
TP-L- 7/8	7/8	1 13/16	1 7/32	1 5/16	5/16	1/32
TP-L-1	1	1 7/8	9/16	1 11/16	¼	1/32
TP-L-1 1/8	1 1/8	2 1/16	1 9/32	1 7/32	¼	1/32
TP-L-1 ¼	1 ¼	2 ¼	5/8	1 13/32	¼	1/32
TP-L-1 3/8	1 3/8	2 3/8	2 1/32	1 15/32	¼	1/32
TP-L-1 ½	1 ½	2 9/16	1 13/16	1 9/32	5/16	1/16
TP-L-1 5/8	1 5/8	2 ¾	2 5/32	1 23/32	5/16	1/16
TP-L-1 ¾	1 ¾	2 15/16	¾	1 27/32	5/16	1/16
TP-L-1 7/8	1 7/8	3 1/16	2 9/32	1 31/32	5/16	1/16
TP-L-2	2	3 ¼	1 13/16	2 3/32	⅜	1/16
TP-L-2 1/8	2 1/8	3 5/16	2 5/32	2 ¼	⅜	1/16
TP-L-2 ¼	2 ¼	3 ⅜	⅞	2 3/8	⅜	1/16
TP-L-2 3/8	2 3/8	3 ¾	2 9/32	2 ½	⅜	1/16
TP-L-2 ½	2 ½	3 15/16	1 15/16	2 5/8	7/16	3/32
TP-L-2 5/8	2 5/8	4 1/8	2 13/32	2 ¾	7/16	3/32
TP-L-2 ¾	2 ¾	4 5/16	1	2 7/8	7/16	3/32
TP-L-2 7/8	2 7/8	4 7/16	1 1/32	3	7/16	3/32
TP-L-3	3	4 5/8	1 1/16	3 1/8	½	3/32
TP-L-3 1/8	3 1/8	4 13/16	1 9/32	3 ¼	½	3/32
TP-L-3 ¼	3 ¼	5	1 ⅛	3 13/32	½	3/32
TP-L-3 ½	3 ½	5 5/16	1 5/16	3 23/32	9/16	3/32
TP-L-3 ¾	3 ¾	5 11/16	1 ¼	3 29/32	9/16	3/32
TP-L-4	4	6	1 5/16	4 5/32	⅝	3/32

D = 1⅛ B + ½ in. (To nearest 1/16 in.)
H = ⅓ B + 5/16.
C = 1 1/32 B + 1/32 in. (To nearest 1/32 in. greater.)
$d = \frac{B+1}{8}$

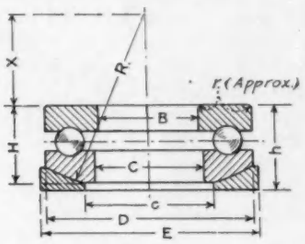
TABLE III—PROPOSED STANDARD INCH SIZES FOR THRUST BALL BEARINGS FLAT-FACE TYPE—MEDIUM SERIES

Bearing Number	B	D	H	C	Ball Dia. d	r
TP-M- ½	½	1 3/8	9/16	9/16	¼	1/32
TP-M- 9/16	9/16	1 9/16	1 9/32	1 1/16	¼	1/32
TP-M- ¾	¾	1 ¾	2 1/32	1 3/16	¼	1/32
TP-M- 7/8	7/8	1 15/16	1 1/16	1 5/16	5/16	1/32
TP-M-1	1	2 1/8	2 3/32	1 1/16	5/16	1/32
TP-M-1 1/8	1 1/8	2 5/16	2 5/32	1 7/32	5/16	1/32
TP-M-1 ¼	1 ¼	2 ½	1 13/16	1 13/32	⅜	1/32
TP-M-1 3/8	1 3/8	2 11/16	2 7/32	1 15/32	⅜	1/32
TP-M-1 ½	1 ½	2 7/8	2 9/32	1 19/32	⅜	1/16
TP-M-1 5/8	1 5/8	3 1/16	1 15/16	1 23/32	7/16	1/16
TP-M-1 ¾	1 ¾	3 ¼	2 11/32	1 27/32	7/16	1/16
TP-M-1 7/8	1 7/8	3 7/16	1 1/32	1 31/32	7/16	1/16
TP-M-2	2	3 5/8	1 1/16	2 3/32	½	1/16
TP-M-2 1/8	2 1/8	3 13/16	1 3/32	2 ¼	½	1/16
TP-M-2 ¼	2 ¼	4	1 3/32	2 3/8	½	1/16
TP-M-2 3/8	2 3/8	4 3/16	1 5/16	2 ½	9/16	1/16
TP-M-2 ½	2 ½	4 3/8	1 7/32	2 5/8	9/16	3/32
TP-M-2 5/8	2 5/8	4 9/16	1 9/32	2 ¾	9/16	3/32
TP-M-2 ¾	2 ¾	4 ¾	1 5/16	2 7/8	5/8	3/32
TP-M-2 7/8	2 7/8	4 15/16	1 11/32	3	5/8	3/32
TP-M-3	3	5 1/8	1 13/32	3 1/8	5/8	3/32
TP-M-3 1/8	3 1/8	5 5/16	1 5/16	3 ¼	11/16	3/32
TP-M-3 ¼	3 ¼	5 ½	1 15/32	3 13/32	11/16	3/32
TP-M-3 ½	3 ½	5 7/8	1 9/16	3 23/32	¾	3/32
TP-M-3 ¾	3 ¾	6 1/4	1 23/32	3 29/32	¾	3/32
TP-M-4	4	6 5/8	1 27/32	4 5/32	11/16	3/32

D = 1⅓ B + ⅝ in. (To nearest 1/16 in.)
H = 0.333 B + 0.396 in. (To nearest 1/32 in.)
C = 1 1/32 B + 1/32 in. (To nearest 1/32 in. greater.)
$d = \frac{B+1}{6}$

Self-Aligning Thrust Ball Bearings—Light Series—Inch Dimensions

Proposed inch dimensions for light series self-aligning thrust ball bearings are shown in Table IV.



Self-Aligning Thrust Ball Bearings—Medium Series—Inch Dimensions

Proposed inch dimensions for light series self-aligning thrust ball bearings are shown in Table V.

TABLE IV—PROPOSED STANDARD INCH SIZES FOR THRUST BALL BEARINGS SELF-ALIGNING TYPE—LIGHT SERIES

Bearing Number	Bearing								Washer		
	B	D	H	C	X	R	Ball Dia. d	r	h	E	c
TS-L- ½	½	1 3/16	.48	9/16	0.72	1 1/4	3/16	1/32	1 3/32	1 1/4	1 1/16
TS-L- 5/8	5/8	1 3/8	0.52	1 1/16	0.86	1 3/16	3/16	1/32	9/16	1 3/16	2 5/32
TS-L- ¾	¾	1 9/16	0.55	1 3/16	1.01	1 3/8	3/16	1/32	1 9/32	1 3/8	1 5/16
TS-L- 7/8	7/8	1 11/16	0.59	1 5/16	1.14	1 13/16	3/16	1/32	2 1/32	1 3/4	1 1/16
TS-L-1	1	1 3/8	0.62	1 1/16	1.29	2	1/4	1/32	1 1/16	1 13/16	1 7/32
TS-L-1 1/8	1 1/8	2 1/16	0.66	1 5/32	1.49	2 1/4	1/4	1/32	2 3/32	2 1/8	1 1 3/32
TS-L-1 1/4	1 1/4	2 1/4	0.69	1 1 1/32	1.63	2 5/16	1/4	1/32	3/4	2 5/16	1 1 5/32
TS-L-1 3/8	1 3/8	2 3/8	0.73	1 1 5/32	1.77	2 3/8	4 1	1/32	1 5/16	2 1/2	1 1 5/32
TS-L-1 1/2	1 1/2	2 5/16	0.76	1 1 5/32	1.91	2 13/16	5/16	1/16	2 7/32	2 5/8	1 3/4
TS-L-1 5/8	1 5/8	2 3/4	0.80	1 2 5/32	2.04	3	5/16	1/16	2 9/32	2 13/16	1 2 9/32
TS-L-1 3/4	1 3/4	2 15/16	0.83	1 2 7/32	2.26	3 1/4	5/16	1/16	1 5/16	3	2
TS-L-1 7/8	1 7/8	3 1/16	0.87	1 2 1/32	2.33	3 3/8	5/16	1/16	2 1/32	3 5/16	2 5/32
TS-L-2	2	3 1/4	0.91	2 5/32	2.40	3 1/2	3/8	1/16	1	3 3/8	2 5/32
TS-L-2 1/8	2 1/8	3 7/16	0.94	2 1/4	2.60	3 3/4	3/8	1/16	1 1/32	3 1/2	2 7/16
TS-L-2 1/4	2 1/4	3 5/8	0.98	2 5/16	2.81	4	3/8	1/16	1 1/16	3 11/16	2 9/16
TS-L-2 3/8	2 3/8	3 3/4	1.01	2 1/2	2.88	4 1/8	3/8	1/16	1 1/8	3 7/8	2 11/16
TS-L-½	2½	3 15/16	1.05	2 5/8	3.09	4 3/8	7/16	3/32	1 3/32	4 1/16	2 7/32
TS-L-2 5/8	2 5/8	4 1/8	1.08	2 3/4	3.17	4 1/2	7/16	3/32	1 5/16	4 1/4	2 11/32
TS-L-2 3/4	2 3/4	4 5/16	1.12	2 7/8	3.38	4 3/4	7/16	3/32	1 1/4	4 7/16	3 3/32
TS-L-2 7/8	2 7/8	4 7/16	1.15	3	3.58	5	7/16	3/32	1 9/32	4 9/16	3 1/4
TS-L-3	3	4 5/8	1.19	3 1/8	3.65	5 1/16	1/2	3/32	1 5/16	4 3/4	3 3/8
TS-L-3 1/8	3 1/8	4 13/16	1.22	3 1/4	3.86	5 3/8	1/2	3/32	1 3/8	4 15/16	3 1/2
TS-L-3 1/4	3 1/4	5	1.26	3 1 3/32	3.93	5 1/2	1/2	3/32	1 13/32	5 1/8	3 21/32
TS-L-3 1/2	3 1/2	5 5/16	1.33	3 1 1/32	4.08	5 3/4	9/16	3/32	1 1/32	5 5/16	3 25/32
TS-L-3 3/4	3 3/4	5 11/16	1.40	3 2 9/32	4.49	6 1/4	9/16	3/32	1 9/16	5 13/16	4 3/16
TS-L-4	4	6	1.47	4 5/32	4.77	6 5/8	5/8	3/32	1 5/8	6 3/16	4 15/32

D = 1⅝ B + ½ in. (To nearest 1/16 in.)
H = 0.283 B + 0.339 in. (To nearest 1/100 in.)
C = 1 1/32 B + 1/32 in. (To nearest 1/32 in. greater.)
R = 1.54 B + 0.471 in. { To nearest 1/16 in. for B less than 2 in. / To nearest ⅛ in. for B = 2 in. or greater. }
$d = \frac{B+1}{8}$
h = 0.314 B + 0.370 in. (To nearest 1/32 in.)
E = 1.406 B + 0.531 in. (To nearest 1/16 in.)
c = 1.086 B + 0.117 in. (To nearest 1/32 in.)

TABLE V—PROPOSED STANDARD INCH SIZES FOR THRUST BALL BEARINGS SELF-ALIGNING TYPE—MEDIUM SERIES

Bearing Number	Bearing								Washer		
	B	D	H	C	X	R	Ball Dia. d	r	h	E	c
TS-M- ½	½	1 3/8	0.62	9/16	0.77	1 7/16	1/4	1/32	1 1/16	1 7/16	2 3/32
TS-M- 5/8	5/8	1 9/16	0.67	1 1/16	0.90	1 5/8	1/4	1/32	2 3/32	1 5/8	2 7/32
TS-M- ¾	¾	1 3/4	0.71	1 3/16	1.03	1 13/16	1/4	1/32	2 5/32	1 13/16	1
TS-M- 7/8	7/8	1 15/16	0.76	1 5/16	1.16	2	5/16	1/32	2 7/32	2 1/16	1 1/8
TS-M-1	1	2 1/8	0.81	1 1/16	1.35	2 1/4	5/16	1/32	2 9/32	2 1/4	1 1/8
TS-M-1 1/8	1 1/8	2 5/16	0.86	1 3/32	1.47	2 7/16	5/16	1/32	1 5/16	2 7/16	1 1 3/32
TS-M-1 1/4	1 1/4	2 1/2	0.90	1 1 1/32	1.60	2 5/8	3/8	1/32	1	2 5/8	1 9/16
TS-M-1 3/8	1 3/8	2 11/16	0.95	1 1 5/32	1.73	2 13/16	3/8	1/32	1 1/16	2 13/16	1 1 1/16
TS-M-1½	1½	2 7/8	1.00	1 1 9/32	1.86	3	3/8	1/16	1 3/32	3	1 1 3/16
TS-M-1 5/8	1 5/8	3 1/16	1.05	1 2 3/32	2.04	3 1/4	7/16	1/16	1 5/32	3 3/16	1 2 1/32
TS-M-1 3/4	1 3/4	3 1/4	1.09	1 2 7/32	2.12	3 3/8	7/16	1/16	1 7/32	3 3/8	2 5/32
TS-M-1 7/8	1 7/8	3 7/16	1.14	1 2 1/32	2.44	3 3/4	7/16	1/16	1 1/4	3 9/16	2 1/4
TS-M-2	2	3 5/8	1.19	2 5/32	2.63	4	1/2	1/16	1 5/16	3 3/4	2 3/8
TS-M-2 1/8	2 1/8	3 13/16	1.23	2 1/4	2.69	4 1/16	1/2	1/16	1 3/8	3 15/16	2 1 3/32
TS-M-2 1/4	2 1/4	4	1.28	2 3/8	2.88	4 3/8	1/2	1/16	1 1 3/32	4 1/16	2 1 1/16
TS-M-2 3/8	2 3/8	4 3/16	1.33	2 1/2	2.94	4 1/2	9/16	1/16	1 1 5/32	4 5/16	2 1 5/16
TS-M-2½	2½	4 3/8	1.38	2 5/8	3.13	4 3/4	9/16	3/32	1 1 7/32	4 9/16	2 1 5/16
TS-M-2 5/8	2 5/8	4 9/16	1.42	2 3/4	3.34	5	9/16	3/32	1 9/16	4 3/4	3 1/16
TS-M-2 3/4	2 3/4	4 3/4	1.47	2 7/8	3.40	5 1/16	5/8	3/32	1 5/8	4 15/16	3 1/32
TS-M-2 7/8	2 7/8	4 15/16	1.52	3	3.59	5 3/8	5/8	3/32	1 11/16	5 1/16	3 3/8
TS-M-3	3	5 1/16	1.57	3 1/8	3.64	5 1/2	5/8	3/32	1 3/4	5 5/16	3 1/2
TS-M-3 1/8	3 1/8	5 5/16	1.61	3 1/4	3.84	5 3/4	1 1/16	3/32	1 2 5/32	5 1/2	3 5/8
TS-M-3 1/4	3 1/4	5 1/2	1.66	3 1 3/32	4.04	6	1 1/16	3/32	1 2 7/32	5 11/16	3 3/4
TS-M-3½	3½	5 7/8	1.76	3 2 1/32	4.42	6 1/2	3/4	3/32	1 2 5/16	6 1/16	4 1/16
TS-M-3 3/4	3 3/4	6 1/4	1.85	3 2 9/32	4.68	6 7/8	3/4	3/32	2 1/16	6 7/16	4 5/16
TS-M-4	4	6 5/8	1.95	4 5/32	4.92	7 1/4	1 1/16	3/32	2 5/32	6 13/16	4 5/8

D = 1½ B + ⅜ in. (To nearest 1/16 in.)
H = 0.379 B + 0.429. (To nearest 1/100 in.)
C = 1 1/32 B + 1/32 in. (To nearest 1/32 in. greater.)
R = 1.667 B + 0.587 in. { To nearest 1/16 in. for B less than 2 in. / To nearest ⅛ in. for B = 2 in. or greater. }
$d = \frac{B+1}{6}$
h = 0.421 B + 0.471 in. (To nearest 1/32 in.)
E = 1.542 B + 0.667 in. (To nearest 1/16 in.)
c = 1.117 B + 0.148 in. (To nearest 1/32 in.)

DISCUSSION OF BALL AND ROLLER BEARINGS REPORT

F. G. HUGHES:—Among the subjects submitted to the Committee from the Division at the Cleveland meeting was a report on metric sizes of thrust washer bearings, the flat-faced, spherical-faced and steering-knuckle types. At that meeting the Standards Committee approved those types of bearings.

There were submitted further types of inch dimension bearings. These bearings were discussed in the meeting of the Division in Cleveland, have been revised since the Cleveland meeting and have passed by letter vote of the Division.

Those tables as shown represent an entirely new series of inch-size thrust bearings. These bearings are not being made in this country at present, but they represent the rational series of bearings, the dimensions of any one portion of which are proportional completely through the series—a series which is fully as proportionate as the ordinary annular-type bearings.

This series of bearings is now before the Standards Committee as a whole for approval. I might say also that this type of bearing is favored by practically all the makers of this type of bearing in this country as representing the first attempt to coordinate inch sizes of thrust bearings. They predict that it will be a considerable improvement to the trade if this series can be adopted.

DISCUSSION AT SOCIETY MEETING

GEORGE R. BOTT:—The report of the Division as accepted by the Committee contained metric dimensions for flat face and self-aligning thrust-ball bearings. It is believed that these tables require further consideration. I move that these dimensions be referred back to the Division.

(It was voted to accept the remainder of the report of the Ball and Roller Bearing Division for submission to mail vote of the Society.)

SIDE GUIDE & GRIPPER

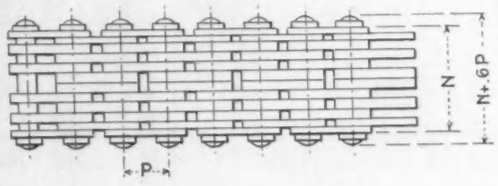
REPORT OF CHAIN DIVISION

(As accepted for submission to mail vote)

AFTER discussion of the limits of pitch that are observed by the various chain manufacturers, the Chain Division recommends that designers of silent chain drives should use the exact nominal pitch of the chain in computing center distances for sprockets.

Widths of Silent Chains

It is recommended that the standard width of silent chains be the width over all tension members and that the maximum width of chain over rivet heads shall be this nominal width plus six-tenths the pitch. The table shows the extreme widths for the various pitches as recommended. Width of sprocket for the same nominal width of chain will vary according to the method of guiding the chain.



WIDTHS OF SILENT CHAINS FOR DIFFERENT PITCHES

Chain Width No.	(N) Width Over Tension Members	EXTREME WIDTH OF CHAIN (N+0.6P)							
		¼-In. Pitch	½-In. Pitch	⅝-In. Pitch	¾-In. Pitch	1-In. Pitch	1¼-In. Pitch	1½-In. Pitch	2-In. Pitch
4	½	0.725	0.800	0.875	....	....	....	....	....
6	¾	0.975	1.050	1.125	1.200	....	....	....	....
8	1	1.225	1.300	1.375	1.450	1.600	....	....	....
10	1¼	1.475	1.550	1.625	1.700	1.850	2.000	....	....
12	1½	1.725	1.800	1.875	1.950	2.100	2.250	2.400	....
14	1¾	1.975	2.050	2.125	2.200	2.350	2.500	2.650	....
16	2	2.225	2.300	2.375	2.450	2.600	2.750	2.900	3.200
18	2¼	2.475	2.550	2.625	2.700	2.850	3.000	3.150	3.450
20	2½	2.725	2.800	2.875	2.950	3.100	3.250	3.400	3.700
24	3	3.225	3.300	3.375	3.450	3.600	3.750	3.900	4.200
28	3½	....	3.800	3.875	3.950	4.100	4.250	4.400	4.700
32	4	....	4.300	4.375	4.450	4.600	4.750	4.900	5.200
40	5	....	....	5.375	5.450	5.600	5.750	5.900	6.200
48	6	....	....	6.375	6.450	6.600	6.750	6.900	7.200

REPORT OF DATA SHEET DIVISION

EVENTUALLY it is proposed to entirely rearrange the Handbook, using Vol. I only for Standards, Recommended Practices and data from reports of the Standards Committee. It is probable that there will be two additional volumes, one containing additional automotive data arranged according to the same general scheme as the new Vol. I, and the other to contain more general engineering data.

Since the necessary rearrangement and revision will require considerable time it is thought advisable to prepare immediately an index of the data in Vol. I classified according to the proposed arrangement of the revised Handbook. This index has been prepared in a preliminary way and when finally ready will be sent out to the members of the Society.

The present plan will make it possible to try out the proposed arrangement extensively before finally adopting it, and any suggestions coming as a result of the try-out can be embodied in the final arrangement.

The proposed "Sections" of the handbook are as follows, the more important of them being divided into sub-classes:

1. Power Plant Section.
2. Clutch and Transmission Section.
3. Final Drive Section.
4. Axle and Wheel Section.
5. Frame and Spring Section.
6. Brake, Steering and Control Section.
7. Body and Hull Section.
8. Accessory Section.
9. Standard Parts Section.
10. Standard Material Section.
11. Complete Vehicle Section.
12. Mathematical Tables Section.

12a. Weights and Measures Section.

13. Mechanical and Electrical Formulas Section.
14. Shop Practice Section.
15. Miscellaneous Section.

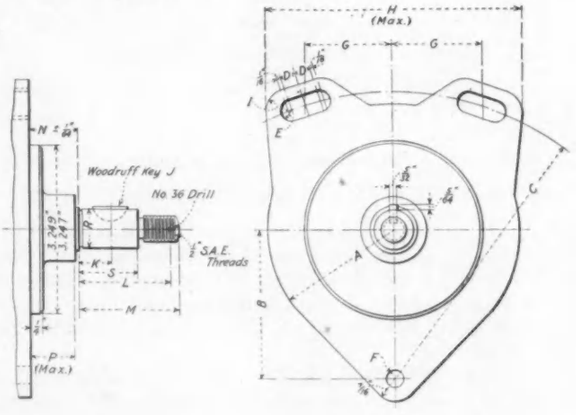
DISCUSSION OF DATA SHEET DIVISION REPORT

A. C. BERGMANN:—This Division reports progress along the lines indicated in our report at the May meeting. In order to try out the proposed classification before rearranging the position of the pages in both volumes, we have decided to provide a set of index pages based on this classification. This index will be useful to the members of the Society during the time required for the revision of the subject matter and form of the volumes.

REPORT OF ELECTRICAL EQUIPMENT DIVISION

(As accepted for submission to mail vote)

TWO sizes of generator flanges as shown are proposed for standardization. Each is provided with a pilot for locating in a bored hole when used with a gear drive and with slotted holes to allow for adjustment for chain drive. In the latter case the hole in the gear case will be made to clear the pilot.

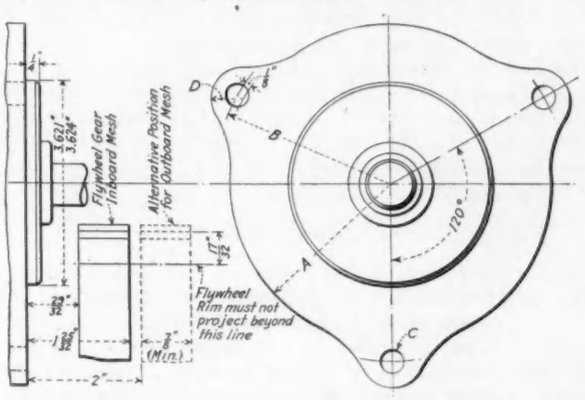


DIMENSIONS FOR PROPOSED STANDARD GENERATOR FLANGE

Size No.	A	B	C	D	E	F	G	H	I	J No.	K	L	M	N	P	R	S
1	2⅜	2 13/16	5⅝	¼	7/32	13/32	1⅝	4¾	7/16	6	9/16	1 11/32	1 11/16	1 3/16	¾	0.6250 0.6245	1
2	2⅜	3 5/16	5⅝	5/16	¼	13/32	1 13/16	5⅝	½	8	11/16	1 25/32	1 15/16	1 11/16	1	0.7500 0.7495	1¼

Flange Mountings for Starting Motors

Two sizes of starting motor flanges are proposed. Standards for pitch of gears are not proposed, but it is recommended that where 8-10 pitch gears are used the pressure angle of the teeth shall be 20 deg.



II—Dimensions for Proposed Standard Starting Motor Flange

Size No.	A	B	C	D
2	$2\frac{11}{16}$	$2\frac{7}{8}$	$1\frac{3}{32}$	$\frac{9}{16}$
3	$2\frac{13}{16}$	$3\frac{1}{8}$	$1\frac{3}{32}$	$1\frac{9}{32}$

Ignition Distributor Mounting

The ignition distributor mounting shown in the accompanying figure is submitted for approval as standard practice. It is suitable for use when mounted either on the engine or on the generator. The shaft diameter is omitted because of difference in practice. The two diameters now in most common use are 0.49 in. and 0.499 in.

DISCUSSION OF ELECTRICAL EQUIPMENT DIVISION REPORT

C. S. Crawford:—I suggest two specifications for generator flange mountings, one with a pilot flange for gear drive and one with a plain flange for the chain drive. With chain drive the time will come for a change of adjustment, when the gasket surface provided will be too small with the necessary hole in the case.

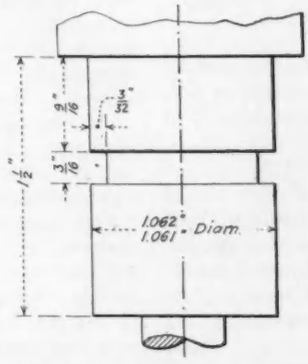
Joseph Bijur:—We usually have to have a sprocket or gear on these generators anyway, and the size of that is somewhere near the dimensions of the pilot. So that in any event it is necessary to have a hole of about that size through which that gear or sprocket can be withdrawn. In considering that, the Division decided to provide for about as large a gear or sprocket as would be likely to be on a shaft, and if the pilot corresponded to those dimensions then it would be unobjectionable. That hole has to be there anyway, and we might as well, therefore, use the same standard for a gear-driven generator as for a chain-driven generator.

C. S. Crawford:—I think the hole is unnecessary for the chain-driven generator. It is necessary to take the gear cover off before the generator can be pulled out; or if the generator is taken off by pulling the sprocket away from the machine, it cannot be put back on without removing the gear cover.

Joseph Bijur:—It is not necessary to take off the gear cover. Frequently a hand-plate or cap is provided; this can be removed and the generator sprocket locked in position by a set-screw in case the camshaft and generator are driven by one chain and it is not desired to disturb the timing. Chain builders are advocating that, to prevent the chain running too loose there should be a little shelf on the chain-case wall near the sprocket, so that if the chain is too loose it will hit that shelf and make a noise. The shelf prevents the chain dropping off, and if the set-screw on the camshaft is tightened so as to hold the timing, then the chain can be loosened, the generator removed and replaced, all without taking off anything but the front cap.

F. L. Morse:—One objection to a large-sized pilot is the adjustment necessary to provide for the looseness of the chain. There is not sufficient packing surface left after it is moved to its position. If the size was decreased there would be some packing surface when the adjustment is made, to prevent leakage. I believe the size is more or less regulated by the gear.

(It was voted to accept the report of the Electrical Equipment Division for submission to the Society.)



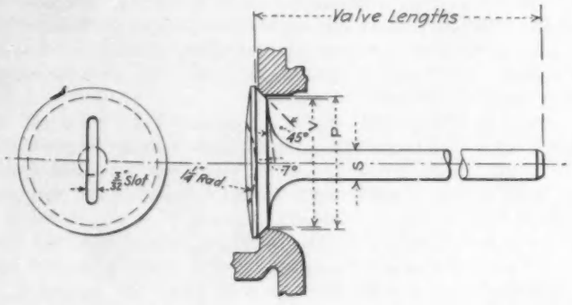
Ignition Distributor Mounting

REPORT OF ENGINE DIVISION

(As accepted for submission to mail vote)

THE recommendations for dimensions of poppet valves that were submitted to the committee in May and referred back to the Division have been revised somewhat, to read as follows:

The nominal valve diameter shall be the port diameter (*P*). The corresponding actual valve diameter and stem diameter are given in the table. The limits for diameters have been selected so as to give proper clearances in guides reamed with commercial reamers.



PROPOSED STANDARD DIMENSIONS FOR POPPET VALVES

P	V	S	P	V	S
1	$^{2}1\frac{1}{32}$	0.3090 0.3100	2	$1^{31}\frac{1}{32}$	0.4335 0.4345
$1\frac{1}{8}$	$1\frac{3}{32}$	0.3090 0.3100	$2\frac{1}{8}$	$2\frac{3}{32}$	0.4335 0.4345
$1\frac{1}{4}$	$1\frac{3}{32}$	0.3090 0.3100	$2\frac{1}{4}$	$2\frac{3}{32}$	0.4335 0.4345
$1\frac{3}{8}$	$1^{11}\frac{1}{32}$	0.3715 0.3725	$2\frac{3}{8}$	$2^{11}\frac{1}{32}$	0.4955 0.4965
$1\frac{1}{2}$	$1^{11}\frac{1}{32}$	0.3715 0.3725	$2\frac{1}{2}$	$2^{11}\frac{1}{32}$	0.4955 0.4965
$1\frac{5}{8}$	$1^{19}\frac{1}{32}$	0.3715 0.3725	$2\frac{5}{8}$	$2^{19}\frac{1}{32}$	0.4955 0.4965
$1\frac{3}{4}$	$1^{27}\frac{1}{32}$	0.3715 0.3725	$2\frac{3}{4}$	$2^{27}\frac{1}{32}$	0.4955 0.4965
$1\frac{7}{8}$	$1^{27}\frac{1}{32}$	0.4335 0.4345	3	$2^{31}\frac{1}{32}$	0.4955 0.4965

A slot is specified for valve grinding tools, to be 3/32 in. wide and made with a cutter having a radius of 1¼ in. The depth of the slot is not specified on account of varying thickness and shape of heads.

DISCUSSION OF THE ENGINE DIVISION REPORT

PROF. W. T. FISHLEIGH:—The Engine Division presents a definite recommendation on the subject of poppet valves and reports progress upon the subjects: hand-starting cranks, engine support-arms, fan design, engine characteristic curves and V-belts. A sub-committee, H. L. Horning, chairman, has gathered designs from automobile manufacturers and crank-makers and suggested standards. Preliminary proposed standards have been prepared, approved by the Division, and submitted to these same manufacturers. The Division is now in possession of valuable suggestions upon which further work will be based.

A special sub-committee, A. F. Milbrath, chairman, has made a preliminary study of the possibility of standardization on certain critical dimensions for engine support-arms, with encouraging results. Information is now being gathered from car assemblers and engine manufacturers with reference to both straight side and taper frames, in an effort to ascertain the possibility of adapting the same standards to either type.

Owing to the present multiplicity of fan designs and methods of attachment, as well as the changes in them now under way, the Division has deemed it wise to refer this matter to the sub-division for study covering a period of months.

Engine Characteristic Curves

With the completion of standard rules and directions for engine tests and of standard curve sheets for plotting the results of such tests, the Division can now continue its work of gathering and classifying engine characteristic curves. It is planned to collect engine characteristic curves based upon tests run under our Standard Rules and Directions and plotted upon the standard forms. Such tests of curves, when classified, will constitute valuable engineering data upon typical engines of various types. Request will be specially made that where special characteristics were aimed at in the designs or adjustment, the same be clearly stated; for example, a consistent high torque over low speed range; low fuel consumption at partial throttle opening, high mechanical efficiency.

It is expected that a report upon extensive tests will soon be presented to the Division, from which work begun last year may be continued.

Poppet Valves

In addition to the items contained in the report the Division has given extended consideration to (a) the diameter of valve at top of valve seat; (b) thickness of valve; (c) radius of fillet under head; (d) radius of head; (e) length of stem, and (f) design and dimensions for spring-retainer fasteners.

In order to not limit designers unduly in the use of various designs of valves, different materials and different spring-retainer assemblies, it is recommended that at the present time these items be not standardized. From the standpoint of interchangeability of valves in different engines these items are of little if any importance.

At the Cleveland meeting of the Committee the Division was asked to reconsider its recommendation providing for ½-in. stem for the valves. Since that time we have gathered data covering the use of this size of valves for at least six or seven years by three or four different makers, in marine engines, airplane engines, racing-car engines and ordinary automobile engines, running at speeds as high as 2200 r.p.m. The evidence seems to be almost entirely in one direction, that the ½-in. stem is adequate, and if trouble has appeared in some few engines having 2¾ or 3-in. valves with the ½-in. stem, it probably has been due to something other than the size of the stem.

A. T. BROWN:—Could the stems be made hollow and of larger diameter?

PROF. W. T. FISHLEIGH:—The recommendation is entirely for solid stems for all sizes of valves.

(On motion, duly seconded, it was voted to accept the report of the Engine Division for submission to the Society.)

REPORT OF LIGHTING DIVISION

(As accepted for submission to mail vote)

THE following terminology is recommended for automobile electric head-lamps and their parts, etc.:

A. Reflector Details.

(*a*) Apex. The Apex is that portion of the reflector to the extreme rear.

(*b*) Rim. The Rim is that portion which retains the reflector in place and which forms no part of the reflecting surface.

(*c*) Reflecting Surface. The Reflecting Surface is that portion of the reflector between the apex and the rim which receives and redirects rays of light.

B. Reflector Support.

The Reflector Support is the means by which the reflector is retained in a permanent position.

C. Lamp Housing.

The Lamp Housing is that portion of the lighting units which forms the exterior shell or case.

D. Lamp Door.

The Lamp Door is the front cover of the Lamp Housing, regardless of the method of attachment.

E. Front Glass.

The Front Glass is that portion of the Lamp Door through which the light is emitted.

F. Prop or Props.

The Prop or Props are that portion of the Lamp Housing by means of which a lighting unit is fastened to its supporting bracket.

G. Lamp Bracket.

The Lamp Bracket is the support on which a lighting unit is mounted by means of its Prop or Props.

H. Lamp Socket.

The Lamp Socket is the receptacle which receives the electric incandescent lamp base.

I. Lamp Socket Adjustment.

The Lamp Socket Adjustment is the device for regulating the position of the Lamp Socket with reference to the reflector.

J. Electric Incandescent Lamp.

An Electric Incandescent Lamp is a light source consisting of a glass bulb containing a filament electrically maintained at incandescence. A lighting unit consisting of an electric incandescent lamp with shade, reflector, enclosing globe, housing or other accessories is also commonly called a "lamp." In such cases, in order to distinguish between the assembled lighting unit and the incandescent light source within it, the latter is often called a "bulb," especially in the automobile industry. The different portions of the Electric Incandescent Lamp may be referred to as follows:

(*a*) *Glass Bulb.*

The Glass Bulb is designated, as regards shape "round" (G-): etc.: as regards size—the glass bulb is measured in eighths of an inch. For example, a G-12 bulb is a round or globular envelope, 12/8-in. in diameter.

(*b*) *Base.*

The Base is that portion of the Electric Incandescent Lamp by means of which it is retained in the socket.

(1) Lock Pins. Lock Pins are small studs projecting from the sides of the base, and serve as a part of the locking device of the bayonet socket.

(2) Base Contacts. The Base Contacts are those portions of the base by means of which electrical contact is made between the socket and the leading-in wires to the filament.

(*c*) *Focusing Length.*

The Focusing Length is the distance along the axis of the base from the center of the filament field to a plane perpendicular to the axis and passing through the locating sides of the lock pins.

(*d*) *Filament Mount.*

The Filament Mount is the entire portion of the Electric Incandescent Lamp composed of filament, leading-in wires and glass stem.

(1) The Filament. The Filament is the light emitting element.

(2) The Leading-in Wires. The Leading-in Wires are that portion of the filament mount by means of which electrical connection is made between the base contacts and the filament.

(3) The Glass Stem. The Glass Stem is that portion of the filament mount by means of which the leading-in wires and filament are supported.

(*e*) *Filament Shape.*

The Filament Shape is the physical form of the filament.

(*f*) *Filament Field.*

The Filament Field is the cross section through the axis of a solid figure formed by the rotation of the filament about the base axis. In the case of the so-called vacuum type helical coil filament, if the axis of the filament itself coincides with the axis of the base, the cylinder formed by the rotation of the filament in this manner would have a rectangular cross section through its axis of a given length and breadth which would be termed "filament field." In this case the filament field would be a cross section of a cylinder enclosing the filament. In like manner, the rotation of a "V" shaped filament, such as is used in the gas-filled type of incandescent lamp, would produce a cone whose triangular cross section through its axis of revolution would be termed "filament field."

The following terminology refers to the light produced by the head-lamps:

K. Light.

Light refers to the luminous radiation emitted from the head lamp, and may be divided under the following sub-headings:

(*a*) *Direct Light.*

Direct Light is the light emitted directly from the filament and emerging from the head-lamp.

(*b*) *Stray Direct Light.*

Stray Direct Light is the light unintentionally changed in direction by the reflection from bulb parts.

(*c*) *Direct Reflected Light.*

Direct Reflected Light is that part of the light emerging from the head-lamp which has been specularly reflected by the reflector in the form of a defined beam of light.

(*d*) *Stray Reflected Light.*

Stray Reflected Light is Stray Direct Light which has been specularly reflected by the reflector.

(*e*) *Diffused Reflected Light.*

Diffused Reflected Light is that part of the emitted light which has been diffusively scattered by the reflector owing to imperfections of reflecting surface.

L. Light Cone.

The Light Cone is the solid angle of light emitted in the form of a cone by the head-lamp, and is subdivided for reference as follows:

(*a*) *Direct Cone.*

The Direct Cone is the direct and stray light from the incandescent lamp passing through the front glass.

(*b*) *Direct Reflected Beam Cone.*

The Direct Reflected Beam Cone is that cone of light formed by the blending of all cones which are produced by the reflected images of the filament and which cones emanate from all points of the reflector upon which light falls. The cone produced in this manner includes only the direct reflected light.

(*c*) *Scattered Light Cone.*

The Scattered Light Cone is that cone of light formed by the blending of all direct, stray direct, stray reflected and diffuse reflected light passing through the front glass.

Focusing Devices

The following are recommended as requirements for focusing devices:

Any socket adjusting device requiring the dismantling of the head-lamp reflector, or the adjustment of which requires handling the bulb, shall be disapproved.

Any focusing device must be constructed so that neither in adjustment nor in use can the bulb base be moved out of its axial position in the reflector.

All socket adjustments must be so designed that they can be locked securely in the desired position.

Focusing Adjustment

It is proposed to standardize the amount of adjustment of the head-lamp socket for focusing the bulb in the reflector. This adjustment is to be such that the locating side of the anchor-pin slot may be placed at any point from 15/16 in. to 1 9/16 back of the focal point of the reflector.

Form of Reflector

It is recommended that all head-lamp reflectors be made as near as possible to the form of a true paraboloid of revolution having a focal length of 1¼ in. from focus to apex.

Head-Lamp Illumination

It is recommended that the "Illumination" paragraph on Sheet 38b, Vol. I of the Handbook be revised to read:

"The head-lamps shall be so arranged that no portion of the direct cone of light, when measured 75 ft. forward of the head-lamps, shall rise above 42 in. from the level surface of the road on which the vehicle stands under all conditions of loading; nor shall any portion of the direct cone of light rise, at the 75-ft. distance, more than 12 in. above the center of the head-lamp."

As passed by the Society in 1916 this paragraph (page 34, Part I, Vol. 11, S. A. E. TRANSACTIONS) reads:

"Head-lamps shall be so arranged that no portion of the beam of reflected light, when measured 75 ft. or more ahead of the lamps, shall rise above 42 in. from the level surface on which the vehicle stands."

Mounting of Head-Lamps

It is proposed to eliminate the following sentence from the paragraph on "Mounting of Head-Lamps" (Data sheet 38b, Vol. I):

"It is found that with a lamp placed high the same intensity of illumination can be obtained with a smaller candlepower than when the lamp is placed low."

The first part of the paragraph, which will remain, reads as follows:

"It is recommended that head-lamps be mounted as high as practicable, and that the centers of tne lamps should never be located less than 3 ft. from the ground."

DISCUSSION OF LIGHTING DIVISION REPORT

W. E. MCKECHNIE:—The Illuminating Engineering Society has appointed a committee on head-lamp illumination, and this Division must work with it in order to get satisfactory results. The I. E. S. committee has agreed to work along scientific lines and help us arrange for the satisfactory use of reconstructed lamps. We are trying to construct the lamp of the future, which would be able so to control the beam of light as to comply with legislative requirements.

A serious question has arisen as regards the ability of incandescent-bulb manufacturers to meet the current demands owing to the wide range of, and various voltages requested by the automobile manufacturers, and the enormous increase in the production of automobiles and the immense increase in renewal lamps required through the incident increase in automobiles operated. It is therefore imperative that the operating voltages for cars using lighting systems that require different numbers of storage battery cells be standardized.

For at least two years engineers of the General Electric Company have studied the service conditions existing on cars using different voltage systems. The Division has had access to these data, and with them in mind has made the recommendations for lighting systems given in the report.

The operating-voltage limits are the ones requested by incandescent-bulb manufacturers in order that they can have somthing tangible to work to; they can then secure as high a degree of efficiency as possible in manufacturing the bulb.

At the last meeting of the Lighting Division, W. F. Little of the Illuminating Engineering Society offered to arrange for tests at the Electrical Testing Laboratories in New York to determine just what amount of light is permissible above 42 in. As the Division is now entering upon the work of classifying the different so-called non-glare devices, it is essential we have some tangible data of this nature upon which to base our report.

The present method of "basing" bulbs makes it difficult to hold within close enough limits the location of the center of the filament field with reference to the locating side of the base lock-pins. We will determine the increased cost required to maintain the position of the filament field so that it never is out of the focus point of the reflector. It may be possible to locate the filament field exactly, or within close enough limits, from the lock-pins in the bulb base, so that focusing adjustments would be done away with and any bulb placed in any reflector would always be in the focal position.

(It was voted to accept the report of the Lighting Division for submission to the Society.)

REPORT OF MISCELLANEOUS DIVISION

(As accepted for submission to mail vote)

Yoke and Eye Rod-Ends

THE Division proposes an extension of the present standards for rod-ends, together with a revision of the limits on drilled holes and pins and an increase in the length of the ½-in. adjustable yoke end. The revised Standards as proposed are shown in Tables I to IV.

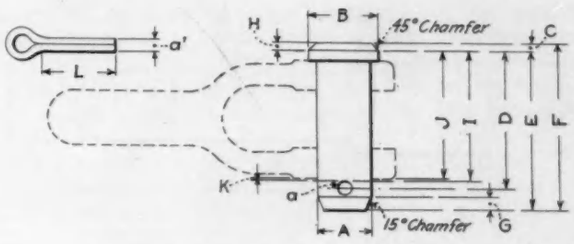
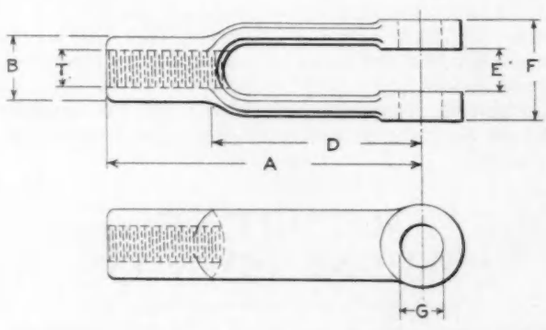


TABLE I—ROD-END PINS

A	Limits of A	B	C	D		E	F	G	H	I	S. A. E. Standard Yoke J		K	Cotter Pin d'		Cotter Pin L	d = Drill No.	d = Drill Dia.	Difference d-d'	Difference +k*
1/16	−0.002 −0.004	5/16	1/16	3 3/64	0.4844	1 9/32	2 1/32	3/64	1/64	0.4464	7/16	0.4375	0.0089	1/16	0.0625	5/16	48	0.076	0.0135	0.0224
1/8	−0.002 −0.004	3/8	3/32	4 3/64	0.6719	5 1/64	5 7/64	1/16	1/32	0.6339	5/8	0.625	0.0089	1/16	0.0625	7/16	48	0.076	0.0135	0.0224
5/16	−0.002 −0.004	7/16	3/32	1 3/16	0.8125	3 1/32	1 11/16	3/64	1/32	0.7595	3/4	0.750	0.0095	3/32	0.0937	1/2	36	0.106	0.0123	0.0224
3/8	−0.002 −0.004	1/2	1/8	1 5/16	0.9375	1 3/32	1 7/32	3/64	1/32	0.8845	7/8	0.875	0.0095	3/32	0.0937	5/8	36	0.106	0.0123	0.0218
7/16	−0.002 −0.004	9/16	3/32	1 1/16	1.0625	1 1 5/64	1 2 3/64	3/32	3/64	1.0095	1	1.000	0.0095	3/32	0.0937	3/4	36	0.106	0.0123	0.0218
1/2	−0.004 −0.007	5/8	5/32	1 3 3/64	1.2031	1 2 3/64	1 3 3/64	7/64	3/64	1.1331	1 1/8	1.125	0.0081	1/8	0.125	7/8	28	0.140	0.0150	0.0231
5/8	−0.004 −0.007	13/16	13/64	1 1 5/32	1.4687	1 2 3/32	1 3 9/64	9/64	1/16	1.3987	1 3/8	1.375	0.0237	1/8	0.125	1	28	0.140	0.0150	0.0231
3/4	−0.004 −0.007	15/16	1/4	1 3/4	1.7500	2 3/64	2 1 9/64	5/32	3/64	1.6550	1 5/8	1.625	0.0300	11/64	0.1718	1 1/4	11	0.191	0.0192	0.0335

All dimensions in inches. *Total clearance between yoke and cotter.



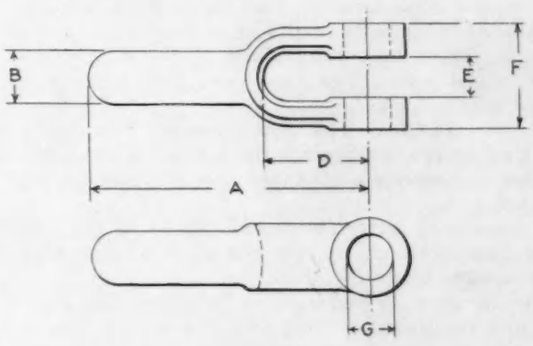


TABLE II—ADJUSTABLE YOKE ROD-ENDS

T	A	B	D	E	F	G	Limits of G
5/16*	1 5/16	5/16	1	3/16	7/16	3/16	+0.001 −0.031
1/4	2	7/16	1 1/4	9/32	5/8	1/4	+0.001 −0.001
5/16	2 1/4	1/2	1 7/16	1 11/32	3/4	5/16	+0.001 −0.001
3/8	2 1/2	5/8	1 5/8	7/16	7/8	3/8	+0.001 −0.001
7/16	2 3/4	2 3/32	1 7/8	1/2	1	7/16	+0.001 −0.001
1/2	4 3/16	1 13/16	3 1/16	9/16	1 1/8	1/2	+0.001 −0.002
5/8	4 15/16	1 1/16	3 11/16	1 1/16	1 3/8	5/8	+0.001 −0.002
3/4	6 1/16	1 1/4	4 5/16	1 3/16	1 5/8	3/4	+0.001 −0.002

*32 U. S. F.

TABLE III—PLAIN YOKE ROD-ENDS

B	A	D	E	F	G	Limits of G
5/16	1 1/4	7/16	3/16	7/16	3/16	+0.001 −0.001
1/4	1 3/4	5/8	9/32	5/8	1/4	+0.001 −0.001
5/16	2	3/4	1 11/32	3/4	5/16	+0.001 −0.001
3/8	2 1/2	2 3/32	7/16	7/8	3/8	+0.001 +0.001 −0.001
7/16	2 1/4	1	1/2	1	7/16	+0.001 −0.001
1/2	2 1/2	1 1/8	9/16	1 1/8	1/2	+0.001 −0.002
5/8	2 1/8	1 7/16	1 1/16	1 3/8	5/8	+0.001 −0.002
3/4	3 1/8	1 11/16	1 3/16	1 5/8	3/4	+0.001 −0.002

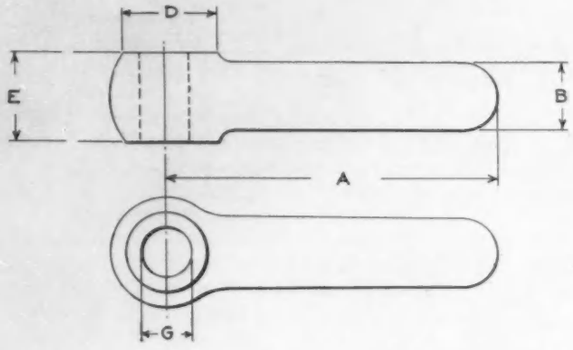


TABLE IV—EYE ROD-ENDS

A	B	D	E	G	Limits of G
1 1/16	5/16	3/8	3/16	5/16	+0.001 −0.001
1 1/4	1/4	1/2	9/32	1/4	+0.001 −0.001
1 3/8	5/16	19/32	11/32	5/16	+0.001 −0.001
1 1/2	3/8	11/16	3/16	3/8	+0.001 −0.001
1 1/2	5/16	13/16	1/2	5/16	+0.001 −0.001
1 3/4	1/2	15/16	5/16	1/2	+0.001 −0.002
2	5/8	1 3/16	11/16	5/8	+0.001 −0.002
2 1/8	3/4	1 5/16	13/16	3/4	+0.001 −0.002

DISCUSSION OF MISCELLANEOUS DIVISION REPORT

E. H. EHRMAN:—The Miscellaneous Division has had under consideration the revision of the rod and yoke ends and parts and the extension of the series. Specific limits have been given to the diameter of the hole in the yoke. The sizes have been extended to include ⅝ and ¾ in.

M. W. HANKS:—The Miscellaneous Division wished to bring before the Society the matter of drawing sizes, so that if possible a standard size of drawing could be selected.

A number of letters were sent out to all the manufacturers asking them to give the sizes of drawings that were used in their factories.

The Division is endeavoring to adopt the 8½ by 11 size and multiples of that, but the letters received do not indicate that those are the popular sizes, and for that reason the Miscellaneous Division wishes to bring the matter before the members of the Committee in order to find what they believe would be the best sizes.

E. H. EHRMAN:—It seems that most of the drawing sizes fall right around and introduce the size that the Division has had in mind for a long time to propose, and that is the standard letter size, 8½ by 11 in. This matter is brought forward now so that the members may have a chance to think about it. The 8½ by 11, being the standard letter size, folds the same as a letter sheet does, files away with the letter and the corners do not have to be folded up, as is the case with the 9 by 12, and it is not lost between the sheets as it is if it is smaller.

Another reason, to my mind, and a good one for the 8½ by 11 size, is that it does not necessitate waste of either blueprint paper or tracing cloth. In fact, it allows us to cut off the selvage of tracing cloth without having it appear on the tracing.

Another point I find is important to others as well as in our own work, and that is that this size gives the men in the factory an opportunity to file their prints. Drawings of the 8½ by 11 size can be put into any of the ordinary transfer files. We use the standard letter files for drawing cabinets, and there are different sizes that will hold the tracings in good shape without any slipping around and rolling the corners up.

We have not gone into multiple and fractional sizes very far, but the half size makes a good one for the shop handbook and can be used for tables and details for which the unit size sheet may be cumbersome.

That is all the Division has to present just now, but when we bring up the subject to the Committee more seriously we hope it will not be turned down just because the popular drawing size may be 9 by 12 inches.

B. B. BACHMAN:—Is there not an unnecessary use of 1/64-in. fractional sizes in the table of the rod-end pins? Why is the 11/64-in. cotter pin recommended for the ¾-in. size?

E. H. EHRMAN:—The cotter pins come in numbered sizes and that is the nearest fractional dimension for the numbered size. It has been our practice to give the pins a fractional dimension instead of a numbered size.

G. E. GODDARD:—Are not the limits (plus or minus 0.001 in.) specified for the holes in the clevis rod-ends closer than necessary for such parts? It is considered good workmanship, I believe, to drill ½-in. or smaller holes within 0.003-in. limits. In heavy production the drill may wear down and be a thousandth under size, but it is more likely to be oversize. I would suggest that the limits be made plus 0.003 or minus 0.001 in.

E. H. EHRMAN:—We believe that for close work, where rattle and the wear caused by the movement of the parts must be guarded against, we must keep the limits close. The limits were put as wide as we thought practicable. We have assumed, however, that the hole will be reamed. The drilled holes can be kept tolerably close to these limits.

(On motion, duly seconded, it was voted to accept the report of the Miscellaneous Division for submission to the Society.)

REPORT OF MARINE DIVISION

(As accepted for submission to mail vote)

The following list of existing S. A. E. Standards is approved for marine uses:

1—Adjustable yoke rod-ends
1a—Plain yoke rod-ends
2—Eye rod-ends
2a—Yoke and rod-end pins
2b—Cotter pins
3—Spark-plug shells
4—Screw standard up to 1½ in.
4a—Screw thread tolerances
4a—Tap drills
4c—Large diameter screw thread
5—Lock washers
7—Square broached fittings
7b—Six-spline fittings
7c—Ten-spline fittings
7d—Four-spline fittings
9—Carbon steels
9—Screw stock
9—Steel castings
9a—Nickel steels
9b—Nickel chromium steels
9c—Chromium steels
9c—Chromium vanadium steels

9d—Silico-manganese steels
9d-9f—Heat treatments
11—Bearing metals
11—Phosphor bronze
12—Brass casting metals
12b and 12c—Manganese bronze sheets and rods
12d—Hard cast bronze
12d—Gear bronze
13—Aluminum alloys
13a—Brass sheets and strips
13b—Brass rods
13b—Tobin bronze rods
13c—Non-ferrous metal tubing
15—Round tension test-specimen
15xa—Flat tension test-specimen (Standard)
15a—Flat tension test-specimen (Alternate)
15xb—Shock test-specimen
15b and 15c—Gray iron test-specimens
15xd and 15d—Brinell hardness test
16—Cold drawn seamless steel tubes
17—Bands and strips
29d and 29e—Roller bearings
35—Carbureter flanges ½ to 2 in.
35xa—Carbureter flanges 2½ to 3½ in.
35a—Flared tube unions
35a—Gasoline pipe sizes
35b—Flared tubes, ells and tees
35b—Throttle levers
35c—Carbureter air heater
35d—Throttle-lever throw
36—Magneto dimensions
36a—Tire-pump base dimensions
38xa—Electric bulb bases, sockets and plug ends
40—Location of engine number
47—Oversize cylinders
47a and 47b—Piston-ring grooves
48-48b—Storage battery directions
48c—Electrical insulation requirements
48n and 48o—Flexible steel tubing

REPORT OF STARTING BATTERY DIVISION

(As accepted for submission to mail vote)

THE Starting Battery Division recommends standard dimensions for battery terminal posts, as follows:

When taper posts are used for battery terminals, the dimensions (in inches) shall be:

Small diameter of negative post	5/8
Small diameter of positive post	11/16
Taper, per foot	1⅓
Minimum length of taper	11/16

When straight terminal posts are used, the diameter of both positive and negative post shall be 13/16 in. and the minimum clear length of the post shall be 13/16 in.

The use of smaller posts is discouraged, but when necessary for small cells the following dimensions (in inches) are recommended for taper posts:

Small diameter of negative post	0.450
Small diameter of positive post	0.5125
Taper, per foot	1⅓
Minimum length of taper	11/16

When necessary for small cells, straight posts are recommended having a diameter of 11/16 in. for both positive and negative, and a clear length of 13/16 in.

Starting Battery Compartment

Starting battery compartments for pleasure cars shall be of metal not less than 18 United States plate gage (0.050 in.), supported entirely on the chassis.

The battery compartments shall be 8 in. wide and 10 in. high in the clear in order to give ¼ in. clearance all around a battery conforming to S. A. E. recommendations. End-to-end assembly of jars is not recommended.

The battery shall rest on two wooden strips each 2 in. wide by ¼ in. thick, running lengthwise of the compartment. These shall be positively spaced with the edges flush with the sides of the battery. Spacers shall be provided to give ¼ in. space at each side of the battery and 1½-in. space at each end outside the hold-down device.

The compartment shall be drained and ventilated.

It is recommended that hold-down devices attach at the level of the top of the battery, not to top of handles.

DISCUSSION OF STARTING BATTERY REPORT

G. E. GODDARD:—The over-all dimensions of the battery case having been standardized previously, it was thought that it would be well to study the battery-compartment standardization as to size, material, location and accessibility. We therefore obtained information from the different automobile manufacturers showing the location of the battery in the several models, as to fore-and-aft position, height in relation to the frame side member, and also on which side of the car the battery was placed.

It was found that nearly all the manufacturers used the S. A. E. standard sizes; in fact, the exceptions were very few.

The location on the chassis of most of the batteries was not what we would recommend as a standard. It was found that a great number of them were under the front seat. As the companies become larger they generally build different types of bodies or a greater number of types of bodies, and it should be a big advantage to have the position of the battery on the chassis independent of body size or seat arrangement. In closed bodies the separate seats, with a passageway between, sometimes are on pedestals leaving no room for the battery above the floor. The runabout seat is likely to be back farther than the touring-car seat. It was for that reason that we decided to recommend that the compartment be placed on the chassis. Of course, most engineers have long ago gotten away from placing batteries on the running-board. We therefore decided to put it inside the frame.

A battery too far off, or at the rear of the car, is subjected to slopping of the acid, and it was decided that it be put as near the center of the car as possible, and below the surface of the frame, more particularly on account of the body variation, but also so that the battery would be part of the chassis. The chassis could then be used independently of the body for testing in the manufacturing, repairing or overhauling of a car. It was therefore recommended that the battery should not project above the chassis frame. This makes it readily accessible, as the floor boards on most cars are not held down. This gives more space under the front seat for tools, which space, of course, is getting smaller every day, on account of seats being carried as low as possible.

It is also recommended that there be spacers on each side of the battery so as to give a 1½-in. space at each end of the battery exclusive of the hold-down device. This was done so that it would be possible to equip a car with a larger battery than that sent out by the manufacturer.

Proper Battery Location

BRUCE FORD:—The majority of automobile manufacturers are still inclined to look upon the battery as a nuisance, and put it in anywhere on the car. Some attention ought to be paid to the location of the battery with respect to the kind of air it gets. If all the air

that reaches the battery has to go through the radiator and pass the engine, and if in addition to that the battery is put close to the exhaust pipe, we are apt to hear complaints that the battery frequently requires filling with water.

W. E. McKECHNIE:—When the storage battery is placed under the floor-boards of the car some kind of baffle-plate is absolutely necessary to protect the battery box itself from the heat, which is driven back under the floor boards. We have found that batteries installed under these floor-boards have to be replenished with water just about twice as often as when they are placed outside or away from the direct drive of the heat from under the hood.

G. W. SMITH:—I do not remember having seen many cars with the battery under the floor-boards. The pedals and transmission are on one side, the exhaust pipe and probably a tire pump and other parts on the other. I think that that is not a good place to put the battery.

JOSEPH HUSSON:—Has the Division investigated the method of mounting these batteries, especially on trucks? Owners have experienced a great deal of trouble, owing to the use of solid tires.

CHAIRMAN UTZ:—The report refers directly to passenger vehicles. The Division is undoubtedly working along the other lines, too.

A. LUDLOW CLAYDEN:—I move that we refer back to the Division the question of location. In many cars it would be really impossible to put the battery under the floor-boards on either side, owing to other accessories. If we have a standard size of battery container the car builders will soon find the best place to put it.

W. H. CONANT:—We find that on many business cars the battery is placed under the front floor-boards. We find that on others it is under the seat, and that a very few are in other locations. This certainly is not too soon to begin the effort to adopt some uniform location for it. Perhaps the position under the floor-boards is not ideal; perhaps one under the seat, or under the tonneau floor, is undesirable for other reasons. The Division has tried to recommend some standard location that will be beneficial not only from a production standpoint but from a service standpoint as well.

W. S. HOWARD:—The Division does not seem to consider the use of batteries for marine work, and for the larger machines that require a 24-volt battery. The new government specifications call for cranking the engine for thirty minutes. The battery is usually placed in a locker. The form of the batteries should be such that they will go in lockers. When the battery has to be recharged in marine work it usually must be transported somewhere; straps should be provided for handling it. I think it would be in order for the Division to study the requirements of the Marine Division.

(It was voted to refer the matter of the battery location back to the Division, and accept the rest of the report for submission to the Society.)

DISCUSSION AT SOCIETY MEETING

C. W. McKINLEY:—I would like to know why it is recommended that no part of the compartment, including cover or fastenings, shall project above the chassis frame.

W. H. CONANT:—It was desired to make the chassis independent of the body or of any particular body style; that is, the chassis would be complete in itself, and could be operated without the body.

C. W. McKINLEY:—We have had a little experience with the mounting of batteries in that position, and it makes it very awkward to protect them from mud and extremely hard to get at to refill or inspect. If they are mounted in the body or so that the upper portion is under the front seat or in some similar position, it is easy for the owner to give it the necessary attention.

(It was voted to accept the report of the Starting Battery Division for submission to mail vote of the Society, after striking out the provision that the battery should be under the floor-boards and should not project above the chassis frame.)

REPORT OF TIRE AND RIM DIVISION

(As accepted for submission to mail vote)

THE Division recommends that the inflation pressures given in the table be standardized, the load per tire and the pounds per square inch inflation being maximum values.

CARRYING CAPACITIES AND INFLATION PRESSURES OF PNEUMATIC TIRES

Size of tire, in.	Maximum load (lb. per tire)	Corresponding inflation pressure (lb. per sq. in.)
3	375	45
3½	570	55
4	815	65
4½	1100	75
5	1300	80
5½	1700	85
6	2000	90

DISCUSSION AT SOCIETY MEETING

J. E. HALE:—In the third column in the table, which is headed, "maximum inflation pressure," should be written "corresponding inflation pressure." For instance, we recommend 375 lb. maximum load for a 3-in. tire; the inflation pressure should then be 45 lb. per sq. in., and that is the corresponding pressure. More weight can be on the tire, but then the inflation pressure must be increased. Mr. Clayden wished to call attention to the fact that in the middle column, the increment of load-carrying capacity is uneven; that is, from the 4½ to 5-in. tire it is 200 lb., and then from the 5 to 5½-in. tire, 400 lb., and from the 5½ to 6-in. tire, 300 lb. We want to go on record as believing that that is inconsistent. The explanation is that the 5 and 4½-in. tires fit the same rim; consequently, the former should not be loaded so heavily, and the increment between them is smaller.

I would like to ask why this report does not cover standards for solid-tire demountable fastenings.

J. G. UTZ:—The standards referred to are purely military standards, and were dictated more or less by the War Department, the work of the Standards Committee being of a cooperative nature. I believe that the Society as a whole and the Standards Committee as a whole should not go on record as calling these military standards S. A. E. standards, because they are strictly for military work.

(It was voted to approve the report of the Tire and Rim Division for submission to mail vote of the Society, the table to be changed as suggested by Mr. Hale.)

REPORT OF TRACTOR DIVISION

(As accepted for submission to mail vote)

IT is recommended that manufacturers rate their tractors by two ratings, drawbar and belt power, as determined below.

Drawbar Rating

The drawbar rating shall be 80 per cent of the power that the tractor is guaranteed to develop at the drawbar continuously for two hours, the tractor being in good condition and properly operated at rated engine speed. The tests should be taken on ground sufficiently firm to give the traction wheels a good footing, a firm sod being preferable.

Belt Power Rating

The belt power rating shall be 80 per cent of the power the engine is guaranteed to deliver at the belt pulley continuously for two hours, the tractor being in good condition and properly operated at rated engine speed.

Belt Speed

We recommend a belt speed of 2600 ft. per min. for all tractors, this being the speed which corresponds to the belt speed of a good average tractor and will meet the widest range of conditions.

Height of Drawbar

We recommend for adoption 17 in. height of drawbar, this being an average that takes into consideration the increased depth of plowing and the running conditions.

Plowing Speed

We recommend the adoption of a standard plowing speed of 2 1/3 m.p.h.

Magneto Dimensions

We recommend for adoption the standard S. A. E. magneto dimensions. We recommend for adoption 0.750 in. as the diameter of the engine magneto drive-shaft, the engine to take magneto coupling, and that this coupling be held on with a key and pin, the size of which is to be determined in connection with later standardization.

DISCUSSION OF TRACTOR DIVISION REPORT

FRED GLOVER:—It is difficult to make a start on the tractor standards because the manufacturers are not used to standardization. We wish to adopt a standard rating at the beginning because the tractor manufacturer rates his tractor at almost any value he wishes to give it. The result is that the tractor manufacturer who rates his machine too high has an undue advantage and can get a higher price, and the manufacturer who rates his low has a hard time to get the proper price.

Proper Tractor Rating

The 80 per cent rating is recommended because with it the farmer will operate his tractor at what practically all manufacturers agree is about the proper load. We found none who wanted to rate their tractors at the maximum at which they would perform for two hours. The footing of tractors is very essential, because they work on soft ground and hard ground. The kind of footing must be specified, because in many places it would be such that the tractor would not deliver any drawbar horsepower at all. If the ground is soft enough it has all it can do to pull itself.

At present manufacturers are furnishing tractors equipped with belts that give a belt speed anywhere from 1500 to 3300 ft. per min.; but we have taken as a basis for our belt speeds the speed of the separator and the threshing machinery. If the belt speed of the engine is not practically the same on all tractors it gives a great deal of trouble to get threshers to run at proper speeds, and if they do not run at the proper speed a good job of threshing is not practicable. Therefore, we recommend a belt speed of 2800 ft. per min. for all tractors, this being the speed obtained with a good average tractor and meeting the widest range of conditions.

The steam engines for many years have been driving threshing machinery and in practically all of them a 42-in. pulley running at 240 r.p.m. has been used. This gives practically 2600 ft. as the belt speed. We believe it is practical for all engine manufacturers to reach this limit. Then all manufacturers of belt-driven machinery could equip it with the same size of belt. It is a problem in manufacturing rather than in engineering.

We recommend for adoption a 17-in. height of drawbar; this is an average that takes into consideration increased depth of plowing, the conditions met in running with wheels in the furrow and the standards used by plow manufacturers. We feel that height will be acceptable to all manufacturers.

Importance of Standard Plowing Speed

We recommend the adoption of a standard plowing speed of 2 1/3 m.p.h. The plows made now by the implement manufacturers are always bent over a trifle to permit higher speed. If they go a little faster it is better than if they go more slowly, as the plows may not scour in the ordinary soil conditions. Consequently we have recommended 2 1/3 m.p.h., which we believe is a good compromise.

The standardization on plowing speed is important, because if one manufacturer gears his tractor to run 1¾ m.p.h., it naturally can pull more plows than the one geared to run 2½ m.p.h. The farmer is prone to judge the tractor by the number of plows it will pull at any speed. It would be more equitable all around if the manufacturers would design their machines to run at some certain speed, or approximately at that speed, and we believe that all manufacturers will agree to this. This applies only to the plowing speed. If the manufacturer wishes to have two or three speeds in his tractor he can do so, as long as it will have that one standard speed. That also helps the plow manufacturers, because the mold-boards have to be at a certain pitch, depending on the speed at which the tractor travels; this speed will not necessitate any change of the mold-boards as they are now manufactured.

Punching Driving Wheels

We have considered the standardization of punching of driving wheels so as to facilitate the manufacture and interchangeability of standard lugs. Some tractors are working in the rice fields, some working in the lava ash of Oregon, some in the East working under varying conditions, and all these require different lugs. We believe it is desirable to standardize the rim punching, so that the same lug will fit any tractor.

Carbureter Fittings

We also report progress in regard to carbureter fittings and will soon be ready to make a report with respect to flanges for heavy kerosene carbureters. Some manufacturers have attempted to use the S. A. E. standard

flanges, but they are not large enough for kerosene carbureters. We also wish to report progress on a standard coupling for agricultural implements; the idea being to enable the farmer to use on his implements a coupling that will fit any tractor in the field. At present the farmer has to make a new hitch so that the implement he buys will fit his tractor. If we fit the tractor with a standard hitch the implement manufacturer will equip his product to correspond, so that it will fit any make of tractor without change.

Subjects for Miscellaneous Division

We suggest that the following subjects be turned over to the Miscellaneous Division for action:

Standardization of ball-and-socket joints for magneto and carbureter manipulation. These are required for tractors in all sizes, and particularly in the size larger than that used on passenger cars.

Yoke and eye rod-end standards to be carried up to 1-in. nominal size. Those are necessary for tractors.

Steering-gear connecting-rods to be standardized as far as possible so as to facilitate the manufacture of both trucks and tractors.

Tractor Nomenclature

We would also like to inquire if it would be in harmony with other activities of the Society if we appoint a nomenclature committee for tractor practice.

CHAIRMAN UTZ:—The Nomenclature Division will soon meet. That Division has power to call in assistance from all the other Divisions and will be very glad to call on the Tractor Division for assistance.

H. L. HORNING:—The recommendations for tractor standards cover items that are fundamental. They are so broad, so deep and so wide that they will vitally affect nearly every one who has had anything to do with tractors. The Division had done a great deal of work in order to arrive at the recommendations.

We have picked out the fundamental things with the idea of doing a few of them well and letting that work stand as a sort of monument and encouragement for more work along this line.

(It was voted to accept the report of the Tractor Division for submission to the Society.)

DISCUSSION AT SOCIETY MEETING

J. G. UTZ:—The Tractor Division has six standards ready for approval. They are all really basic to the tractor industry, and will be the very first ray of sunshine in the matter of standardization.

H. L. HORNING:—I suggest that we amend the recommendation relating to speed so that it applies to tractors of 15 drawbar hp. and under.

C. W. KELSEY:—It seems to me that the speed of tractors might be greatly increased, and that there is not enough information about them at present to recommend any definite speed. The limit now seems to be the rate at which plowshares will stand up.

Difference in Tractor Speeds

H. L. HORNING:—There has been a great deal of confusion up to this time on account of the different speeds. Farmers usually value a tractor by the number of plows that it can pull and not by the speed, because the number of plows can be counted and the miles per hour can only be estimated. The object of standardizing the speed is not to fix it for all time. That would be a disadvantage. We are going to learn something, but at this time the science of plowing and the question of speed are well understood. The man coming in from the outside, who usually has made passenger-car and racing-car engines, and is trying to make up in speed what he loses in the number of plows, is demanding the higher speeds. The lesson is that speed may be an incentive for development work that will lead us up to better performance.

We recognize definitely that the speed will be increased. As a matter of fact, we had fixed 2¼ m.p.h., which is about 200 ft. a min., but we recognized the general tendency upward, and therefore took 2 1/3 m.p.h. as representing better practice at this time. We do not want to stop there. In a few years we will know more about making plows for tractors and we can use a curve in our mold-board that will accommodate a wide set of conditions, and at the same time will allow us to use a higher speed. As the speed is increased, the scouring is better and the plow keeps cleaner, and that is an important factor in favor of the increase.

(It was voted to accept the report of the Tractor Division as revised, to apply to tractors of 15 drawbar hp. and under, for submission to mail vote of the Society.)

ATTENDANCE AT SEMI-ANNUAL MEETING

MEMBERS

ABELES, JAMES, vice-president, Motor Car Equipment Co., *New York.*
ACKERMANN, A. H., secretary-treasurer, Bradford-Ackermann Corp., *New York.*
ADAMS, HUGH L., vice-president, Edw. G. Budd Mfg. Co., *Philadelphia.*
ADDIS, CHARLES M., service manager, New York Lubricating Oil Co., *New York.*
AKIMOFF, N. W., research engineer, *Philadelphia.*
ALBORN, F. G., designing engineer of trucks, Locomobile Co. of America, *Bridgeport, Conn.*
ALLEN, WALTER C., sales manager, Bijur Motor Lighting Co., *Hoboken, N. J.*
ALLEN, W. H., assistant superintendent, B. F. Goodrich Co., *Akron, Ohio.*
AMMON, MARK A., metallurgist, Willys Overland Co., *Toledo, Ohio.*
AMOS, C. L., president, Dyneto Electric Corp., *Syracuse, N. Y.*
ANDERSON, ROBERT M., acting professor of engineering practice, Stevens Institute of Technology, *Hoboken, N. J.*
ANDERTON, HARRY C., sales manager, John O. Heinze Co., *Springfield, Ohio.*
ANDREWS, GEORGE C., president, Andrews Heating Co., *Minneapolis.*
ANIBAL, B. H., designer, Cadillac Motor Car Co., *Detroit.*
APPLE, VINCENT G., proprietor, Vincent G. Apple Developing Laboratories, *Dayton, Ohio.*
ARTHUR, PAUL, mechanical engineer, Simms Magneto Co., *E. Orange, N. J.*
BACHMAN, B. B., engineer, The Autocar Co., *Ardmore, Pa.*
BACON, GEO. M., electrical engineer, Anderson Electric Car Co., *Detroit.*
BALDWIN, HENRY S., engineer, General Electric Co., *West Lynn, Mass.*
BANINGER, JOHN H., service engineer, Gurney Ball Bearing Co., *Jamestown, N. Y.*
BARTER, PERCY L., sales manager, McCord Mfg. Co., *Detroit.*
BARTON, CHAS. E., research engineering department, Packard Motor Car Co., *Detroit.*
BARTON, HENRY L., production engineer, General Motors Co., *Detroit.*
BARTON, VICTOR N., student, Columbia University, *New York.*
BATT, W. L., sales manager, Hess-Bright Mfg. Co., *Philadelphia.*
BEACH, CLARENCE H., sales department, Midvale Steel Co., *Philadelphia.*
BEABER, WM., JR., secretary, Whitmore Mfg. Co., *Cleveland.*
BEAVER, H. L., salesman, Atlas Ball Co., *Philadelphia.*
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TOBIN, B. F., president, Continental Motors Co., *Detroit.*
TRAVIS, E. A., Locomobile Co. of America, *Bridgeport, Conn.*
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VAN METER, MORTON.
†VAN RIPER, L. C., Eureka Engine Co., *Detroit.*
VOUGHT, C. M., Lewis & Vought Corp., *New York.*
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†WEMP, E. E., Denby Motor Truck Co., *Detroit.*
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WILLIAMS, LEROY J., Cadillac Motor Co., *Detroit.*
WILLIAMS, A. F., JR., assistant sales manager, Winther Motor Truck Co., *Kenosha, Wis.*
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WINKLEY, F. H., General Electric Co., *Schenectady, N. Y.*
WISE, K. L., Detroit Testing Laboratories, *Detroit.*
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Ignition Units on Aviation Engines

By ROGER E. G. CHAUVEAU,* (*Member of the Society*) *Illustrated with* PHOTOGRAPHS AND CHART

The fact that most of the designers of aviation engines have gained their experience from the high-speed and racing-automobile engine has in many cases resulted in designs that exert an unnecessary hardship on the different ignition units. It is the intention with this paper to state briefly some of the troubles experienced on the various fields and outline constructions that will produce the best operating conditions for the different ignition units.

The demand from the present-day high-speed, high-pressure, multiple-cylinder aviation engine has reached the limit of what the ignition system can produce. It is essential, therefore, that the designer should give all possible consideration to producing the most favorable conditions for proper operation of the ignition units; this to a large extent will help to minimize the difficulties encountered on the aviation fields today and will increase the efficiency of the aviation service as a whole.

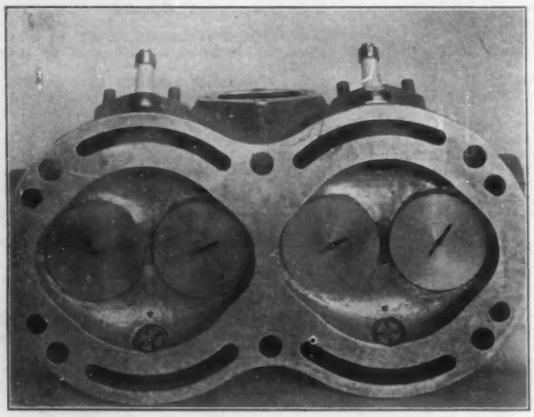

FIG. 1—CYLINDER-HEAD WITH SPARK-PLUG BOSSES IN CENTER-LINE OF WATER STREAM

Until this has been obtained the only way of counteracting the effect of failure in the ignition units is to provide means for quick and easy replacements of the different units, and this important point has, unfortunately, not received sufficient consideration in many cases.

It is evident that a failure that requires several hours of repair work, special tools and skilled workmen is much more serious than one that can be repaired in a few minutes with such tools as are found in an ordinary tool kit.

This becomes vastly more important when engines for military purposes are in question. In such service the different ignition units may fail not only on account of defective material or construction, but from damage caused by projectiles. In changing a couple of spark-plugs under a forced landing, a few minutes' delay because the plugs are hard to get at or because the special claw or socket wrench necessary to screw the plugs down is missing, may mean the loss of the airplane with the crew and equipment.

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The severe strain to which the ignition systems on aviation engines are subjected and which cannot in any way be compared with the conditions on an automobile engine is due to the continuous operation at high speed, higher horsepower output, severe vibrations, high gas pressure and compression and the high operating temperature.

SPARK-PLUG LOCATION

At the present time the spark-plugs cause most difficulties and call for most frequent replacements. These are submitted to the hardest service of any part of the engine. The location of the spark-plugs is in spite of this often the last thing that is determined on the engine layout.

The success of the spark-plugs depends to a large degree on the design of the engine, which has been proved time and again by the fact that a certain make of spark-plug will give satisfactory service on a certain design of engine but will absolutely fail on another design, although the speed, gas pressure and compression may be the same in both cases.

The high temperature in the cylinder of the aviation engine is the factor most detrimental to the spark-plug insulator. The first consideration in the layout is to have it such that as much heat as possible will be carried away from the spark-plugs.

To accomplish this the bosses for the spark-plugs should be located in the center-line of the water stream flowing upward to the outlet pipe and in a position where they are constantly in contact with a large body of rapidly flowing water. Such a construction is shown in Fig. 1. Under no circumstances should the spark-plugs be mounted in places where the water jacket forms a pocket and where the flow of water is slow.

To further increase the cooling effect it is necessary to keep the wall thickness of the bosses or sockets for the spark-plugs as small as mechanical strength will allow. The design of the casting should be such as to allow free inspection of the inside of the water jackets at this point; this will insure that no fins or ribs have been left around the bosses to cause steam pockets and improper cooling.

It is preferable to mount the spark-plugs directly in the cylinder castings and avoid bushings on account of the increased thermal resistance caused by the discontinuity of metal at the joint between the bushing and the cylinder wall.

The surroundings of that part of the spark-plug that extends beyond the cylinder castings should allow the full draft from the propellers to sweep over the top of the insulator. This will tend to cool the upper part of the center electrode, draw the heat from the lower part, and thus help to maintain a lower temperature throughout the insulator. The mounting of the spark-plugs in recesses in between the cylinder castings or behind obstacles, such as water pipes and rocker-arm supports, should therefore be avoided.

The maximum cooling and cleaning effect from the incoming charge of fresh gas is obtained on the electrodes if the spark gap is located slightly inside the cylinder walls and the electrodes are swept by the incoming charge.

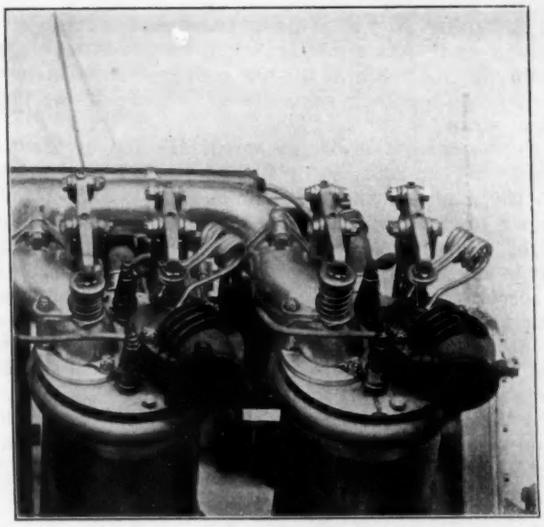


FIG. 2—SPARK-PLUGS LOCATED AS NEARLY VERTICAL AS POSSIBLE, CLOSE TO INTAKE VALVE

The spark-plugs must be mounted as near vertically as possible, Fig. 2, when the engine is mounted in the body, to provide free drainage and avoid excess oil collecting inside the spark-plug shell and causing a short-circuit over the insulator and carbon collection. The plugs should be mounted with not less than 30-deg. inclination to the horizontal, in any case.

Means of easy and quick replacement of spark-plugs are more important than of any other part of the engine. Breakage of the insulator is often caused by improper mounting of the plugs, either because they are screwed down too tightly, causing an unnecessary strain on the insulator, or because they are not screwed down tightly enough and leak, with resulting excessive heating of the insulators.

It is essential, therefore, that there should be sufficient space around the spark-plugs to permit the use of an ordinary S-wrench for mounting the plug and that there should be room enough for the movement of the wrench to allow the operator to feel the tightness of the plug while screwing it down. It is always a temptation for the men on the field, and has been done repeatedly, to use a hammer and a chisel to give the spark-plug a final half turn, particularly when a special wrench is required and not directly at hand. It is obvious that this is a very poor procedure, but the temptation is there, and the human element must be considered.

MAGNETO-DRIVE CONSTRUCTION

Many engine designers have omitted the flexible member in the magneto drive, in the endeavor to avoid unnecessary weight, and have disregarded the effect of the torsional crankshaft vibration on the revolving parts of the magneto.

With a non-flexible drive the crankshaft vibrations will be transmitted to the rotor parts of the magneto even though the drive may be taken through a number of intermediate gears, and the effect of these vibrations has proved very injurious to the magneto armature and in many cases caused loosening of the screws that hold together the different parts of the armature.

The continually increasing tendency to substitute zinc and aluminum die-castings for bronze castings in modern magneto construction is another factor that must be considered. Zinc and aluminum die-castings do not possess the mechanical strength of bronze castings and it is therefore important to relieve the magneto of all unnecessary strain in order to secure satisfactory magneto endurance.

Mounting the drive gear, whether it is of the spur or bevel type, directly on the magneto shaft cannot be too strongly condemned, as this puts an additional load on the magneto shaft, owing partly to the weight but largely to misalignment and poor meshing of the gears.

Poor meshing must be expected whenever magnetos are exchanged or replaced, as it is a practical impossibility to replace a magneto with the gear mounted on the shaft and secure perfect meshing without the use of shims, which again require skilled workmanship.

The additional load on the magneto shaft caused by tight meshing of the gears will tend to shorten materially the life of the ball bearings. While good-grade ball bearings have a practically unlimited life when working under normal load, an excessive load will destroy the ball cages in a very short time.

Successful magneto operation depends, therefore, on the proper application of a flexible drive member, Fig. 3, which should be of such a design as to absorb the torsional vibrations from the crankshaft and yet not cause any appreciable lag in the firing of the engine at high speed—two conditions that are difficult to meet, but which require so much more attention.

A flexible drive will also greatly facilitate quick replacement of defective magnetos. The fact that machining the magneto base on the engine incidentally becomes a much better manufacturing proposition, as less accurate workmanship is required, should not be overlooked by the engine builder.

Provision for timing of the magneto can as a rule be conveniently designed in connection with a flexible drive and must be strongly recommended. The full efficiency of the engine can be uniformly attained only with an adjustable member in the magneto drive. It has often occurred that with direct drive correct timing could not be obtained by the setting of the gears, simply because the best setting would fall between two teeth unless the pitch is small, and this is usually limited by the mechanical strength of the teeth.

It is preferable to have the adjustable feature so arranged that the timing can be made after the magneto is mounted on the engine, and the setting locked and secured without necessitating the removal of the magneto after it is determined.

The magneto should be located so as to secure convenient inspection of the two parts of the magneto most likely to cause trouble, that is, the distributor and the breaker box.

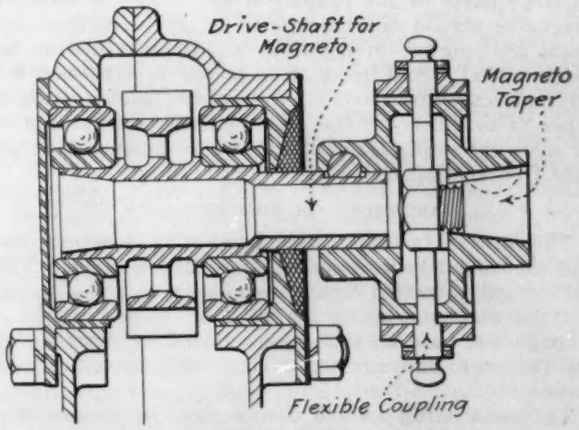


FIG. 3—ARRANGEMENT OF DRIVE-SHAFT FOR MAGNETO WITH FLEXIBLE ADJUSTABLE COUPLING

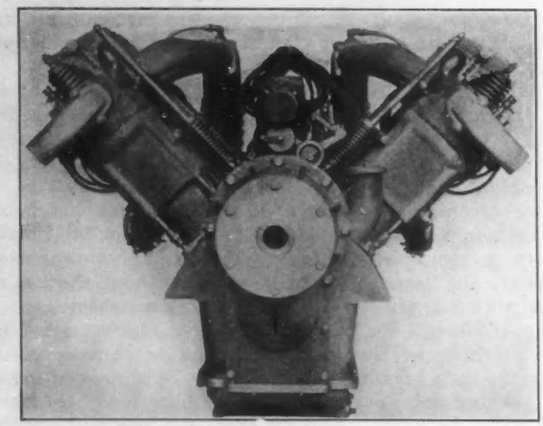


FIG. 4—PROTECTED LOCATION OF MAGNETO INSIDE "V"

Accumulation of carbon dust in the conventional design of distributor with revolving carbon brush has caused more or less difficulty in the past, and it has been found necessary to clean these parts frequently.

The best location on a V-type engine is generally inside the "V," as in Fig. 4, although this to a large degree depends on the design of the body members and the engine bed, but as a rule magnetos mounted on the rear end of the engine on a bracket attached to or integral with the timing gear cover and facing outward to the sides will interfere with the body and prove very difficult to get at.

Another disadvantage connected with the end location of the magnetos is the increased length of the ignition cables. These should be kept as short as possible, partly to reduce a source of trouble, and partly to hold the capacity of the cables low. High capacity will decrease the efficiency of the magnetos when running at extreme high speeds, as on twelve-cylinder geared-down engines, for which speeds of 3300 r.p.m. or better may be necessary. The cables as a rule are shortest when the magnetos are located near the center of the "V."

For engines to be used on seaplanes proper regard must be given to the salt water sprayed through the radiator. The best location of the magnetos would be as high up on the engine as possible, preferably facing astern.

Many of the insulation parts on a magneto are made of hard-rubber or hard-rubber compositions, which are very sensitive to heat and will soften at temperatures around 180 deg. fahr. In view of the high temperature in some parts of the country it can easily be seen that magnetos should not be exposed to any additional heat from the engine, and should not be mounted in any location that would bring them in too close contact with any heat-carrying parts of the engine, such as exhaust pipes or cylinder jackets. Best results will be obtained by allowing ample space all around the magnetos to provide free ventilation.

FASTENING OF THE MAGNETO

The form of fastening must be such as to permit quick and convenient replacement of defective magnetos. The old method, inherited from automobile practice, of fastening the magneto by means of four bolts brought up through the base on the engine should be discarded by the designer, and a more modern and convenient way chosen.

The metal strap around the magneto or a clamp over the top, held down by two long bolts, is undoubtedly the best fastening used at present, provided the strap or the clamp is made of a non-magnetic metal, such as brass or aluminum. As much as 10 per cent loss in efficiency of the magneto has been encountered because of the use of a steel strap.

In some cases the clamps across the top of the magnetos have been replaced by special brackets cast integral with the magneto base-plate or end-plate, and bolted or clamped to the engine. While this may be a satisfactory way of fastening the magneto so far as quick replacement is concerned, it cannot be recommended, as it calls for special features of the magneto, and one of the most important points in engine design is to maintain an absolute interchangeability between all types of magnetos, and strict adherence to the S. A. E. standard dimensions.

Whether straps or clamps are used two heavy dowels should always be provided in the magneto base-plate, in order to secure proper alignment of the magneto and the magneto drive-shaft.

HIGH TENSION WIRING

Fortunately little trouble has been experienced with the high tension wiring, although the designer can improve conditions here also somewhat.

The high tension cables on many engines are mounted inside brass or steel tubings, although it is preferable not to have the cables in contact with any grounded metal part in case a puncture of the insulation should occur.

The safest and most efficient way of wiring the ignition, Fig. 5, is to run the cables through tubes of insulation materials such as micarta or fiber or to string the cables free in the air and support them firmly at intervals by fiber clamps.

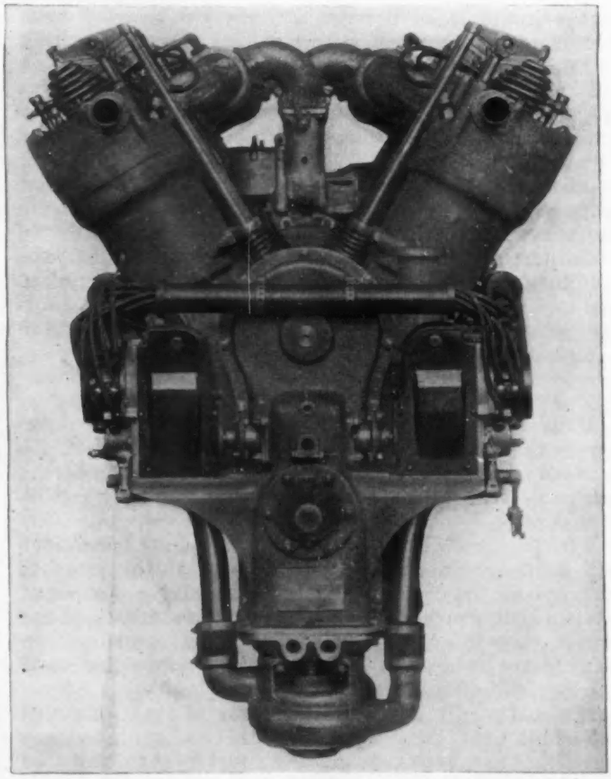


FIG. 5—WIRING OF HIGH-TENSION CABLES IN FIBER TUBES, COMPACT AND WELL PROTECTED

This last method has its advantages, as it permits free inspection of the cables and facilitates tracing them to the different cylinders.

The cables should not, however, in any case come into contact with parts of the engine. The supports must be mounted closely enough together and be of sufficient number to prevent any movement of the cables that would cause chafing and deterioration of the rubber insulation.

SOME FOREIGN DEVELOPMENTS

In the tremendous development in the air service abroad several new ignition features have come up. To overcome the carbon trouble in the distributor some foreign engine designers have mounted the distributor as a unit separate in itself on the end of the camshaft; this permits the use of a large distributor disk whereby the linear distance between the segments can be increased, and leakage of the high-tension current because of the carbon deposit decreased. The larger distributor will also permit the use of a longer timing range, as the length in degrees of the segments can be increased and a longer interval in inches between the segments still maintained than is possible in the standard construction. A construction of this kind is advantageous for high-speed engines and should be considered by American engine designers.

A great amount of work is now being done in this country by ignition manufacturers to bring the different ignition units to the highest degree of development. With the ignition manufacturer and the engine builder working in unison success in securing reliability and satisfactory endurance can soon be hoped for.

Automobile Engine Cooling

By A. K. SCHANZE*
(*Non-Member*)

CLEVELAND SECTION PAPER *Illustrated with* CHARTS

IN taking up the subject of cooling internal-combustion engines on automobiles, the author intended to devote particular time and attention to the fan. However, the performance of the other factors in the cooling system, namely, the radiator, the water jacket and the circulation, is so closely linked with that of the fan that a discussion of the subject would be incomplete did it not take them into consideration.

This paper will deal with water-cooled engines only; air-cooled systems will not be discussed.

The cooling system of the internal-combustion engine as now applied on a majority of passenger cars normally divides itself into four main units: The water jacket around the engine cylinders, the circulating system, the radiator, and the fan.

The order in which these have been named seems to be the order of their importance in the minds of most engineers, consciously or otherwise. It seems also that this is the historical order in which real scientific research and practical development have taken place on the cooling systems now in use.

The author is of the opinion that no order of relative importance can be assigned to these four divisions of the cooling system. They form a chain whose strength is only that of the weakest link, and wherever one of the four falls below its proper standard there lies in the system an imperfection that should be remedied.

Cooling systems give outward evidence of imperfections in two general ways; they overcool or they undercool. Of the two, the latter is far the more common.

WATER-JACKET PROBLEMS

The function of the water jacket is to carry such volume of water that it will take from the cylinder walls only that heat that cannot be converted directly into mechanical energy, and the accumulation of which would be destructive to the cylinder material. From such a definition it would appear that, given the number of heat units generated, the mechanical work to be done, and the heat units in excess of the latter requirement, a water jacket would be a simple matter to design.

Perhaps it is, but its simplicity is a secret in possession of a limited number of engineers. The author, during fan tests that he has conducted on cars of many different makes, has found only three or four apparently ideal water-jacket designs. In the main, water jackets leave some room for improvement.

The mere solution of the problem of what volume of water a jacket must contain does not give the answer to the cooling problem. The distribution of the water layers around the cylinder walls may be of even greater importance than the volume. Ignition takes place in the top of the cylinder, which is longest exposed to fire and becomes hottest. Modern engineering practice has placed the deepest layer of cooling water over the top of the cylinder, which is as it should be. However, it seems to be the foundry practice in some cases to interpose stiffening ribs or small columns on top of the cylinder, which act to retard the circulation, with the result that steam pockets seem to be formed. These are evidenced in some engines whose water-jacket volumes are adequate, in the sudden increase in temperature that takes place when the engine stops.

The author has noticed in several tests that when the engine was stopped the temperature recorded by a thermometer placed in the filler cap mounted 20 deg., from 200 to 220 deg. fahr. We lost two thermometers through having them blown from an improvised bushing in a hole in the filler cap, a jet of steam shooting 20 ft. into the air from a radiator the water in which a moment before had not been near the boiling point. Thermometers lashed in place indicated temperatures of 220 deg. fahr. Repeated experiments could lead only to the conclusion that the whole mass of water was not being raised through that range of temperature in 40 or 50 sec., but that some little patch on top of the cylinder was being converted into steam so fast that the filler neck, which was being used as a steam dome, could not act through the overflow to relieve the pressure.

Whenever a design of water jacket permits such a con-

*Chief engineer, Pitter Fan Company.

dition every effort should be made to get rid of it. The condition is dangerous to the mechanical structure of the machine and also to people working around a car. The mechanical danger is present in radiators in which large areas and thin structures are not designed to carry pressures above the atmosphere. Steam above 212 deg. means such pressures. Many a radiator manufacturer has undoubtedly been called upon to replace leaky radiators that were not really defective.

The danger to human beings lies in the possibility of a clogged overflow pipe and an unsuspecting person looking into the filler neck at the psychological moment. The author saw this happen about a year ago, when a man had his face severely scalded.

Tests conducted by authorities on internal combustion engines indicate that high compression contributes largely to the efficiency of the gas engine. High compression is always attended by the danger of preignition unless the cooling system can overcome the tendency.

If the cylinder walls are cool, the gas entering on the suction stroke does not immediately expand, fill the cylinder, and thus prevent the full calculated quantity entering. It tends to keep its density at a value in accordance with that established by the carbureter, and then the engine gives more nearly its maximum capacity.

In order to prevent the overheating tendency immediately following the shutting down of an engine, it would seem necessary then to give the water in the jacket such volume and distribution as to enable it to absorb the last heat accumulation in the cylinders, independent of the circulating system.

Jacket design, therefore, should be such as to allow liberal distribution of water and freedom of circulation. Since the circulating systems in general use are what may be classed as pressureless systems, the water will only follow the lines of least resistance within the cylinder. Short turns will at least materially resist circulation, and may even prevent it, and thus cause "steam pockets."

The design must be followed up by close inspection of the casting as it comes from the foundry. Too much stress cannot be laid upon this. The outside of a cored casting receives careful inspection to prove its freedom from flaws, but too often the inside is passed as being hopelessly inaccessible to inspection, and is assumed to be satisfactory if the exterior shows that there are no cracks.

TYPES OF CIRCULATING SYSTEMS

Between the pump system and the gravity (thermosyphon) system of circulation there is at present somewhat of a race for supremacy. The pump system frequently overcirculates, or tends to, while the gravity system undercirculates. Both faults are conducive to trouble.

In practically all pump systems the speed of the pump varies with the engine speed. This is logical enough, and conforms with good engineering theory and practice. Rotary pumps must attain a certain minimum speed before they do any effective work. This means that the starting point is considerably above zero, say about 250 or 300 r.p.m. Their efficiency increases after they get up to 500 r.p.m., usually until the speed is 800 or 900 r.p.m.; the result is that when the engine speed is such as to result in heating the pump, which was designed to do its circulating at a car speed of 20 m p.h., is working at high efficiency. In such cases, however, the water is thrown up into the top of the cylinder and the radiator tank faster than the internal friction of the radiator will allow it to return to the pump. The bottom of the radiator is thus one moment empty and the next full, or it may be simply allowing a small part of the water to pass into the pump and a large part to be lost through the overflow pipes. When the radiator is thus, in part, deprived of water, it cannot perform the full amount of cooling action of which it is capable. Overheating, or at least inefficient cooling, results.

It would appear, then, desirable to select a pump speed designed to circulate the water within the limits of the radiator frictional resistance and then always run the pump at that, regardless of engine speed.

In marine work, circulating pumps are used in connection with the steam condensers in exactly the same manner in which they are applied to automobiles, and it has been found that pumps have to be controlled independently of engine speed. Such practice is now universal. The automobile engineer might well investigate the experience of marine engineers along these lines.

Thermosyphon Systems

The gravity or thermosyphon system of circulation, which is in its infancy as regards practical development, has been used with varying success. At best, its impulse is feeble, owing to the lack of head. On this account it succumbs readily to any abnormal frictional resistances that may result from solid matter in the water. It recommends itself because of its simplicity of construction, low initial cost, manifest economy of operation, and the advantages derived from the fact that it continues in operation for some time after the engine stops.

Its practical application to the car so as to realize these advantages is difficult. At present too many of these systems are arranged in almost the same way as the pump system, but with the pump omitted. Best results in gravity circulation, as applied to the heating of dwellings and other buildings, are obtained with the horizontal runs comparatively short as compared with the head pipe. The principle is identical in the automobile. The head pipe must always remain well submerged. This latter feature cannot be accomplished without the use of a reserve storage tank attached to the top of the radiator.

RADIATOR REQUIREMENTS

After the body designer has established the shape of the radiator, and the purchasing agent has fixed its cost limit, the designing engineer can go as far as he chooses. Frontal area should be a maximum, and upon this depends net radiating area.

Radiating area can be considered from a horsepower basis, as the radiating action is exactly the process of doing work. Of the total heat of the engine absorbed by the water we have only to deal with the small residue that would cause overheating if not carried off by the radiator.

A cubic foot of air, in passing through a radiator and being raised 50 deg. fahr. in temperature, absorbs 1 B.t.u. A horsepower represents 42.4 B.t.u. per min., and upon this basis we can arrive at the other results.

The radiator whose heat-transferring qualities are such as to give a uniform rise of temperature to all air passing through it, regardless of the velocity of the air, is an ideal not beyond our reach. Some are in existence that so closely approach this condition as to be considered perfect for all practical purposes.

For efficiency not only is it necessary to have the air passages free from solder obstructions, but it is just as important that they be of a size and shape that will give

a good smooth run to the air. The more air that can be passed through a radiator the greater will be its cooling power.

We must also look carefully at the inside of a radiator to determine its capacity and the freedom with which water can circulate. On several occasions tests have shown that capillarity was preventing free circulation. This condition is too well known to radiator designers to need comment, but the fault does occur occasionally, and is probably due more to workmanship than design.

Core depths of as much as 4 in. are in common use, and have their purpose. Since expense is increased with core depth it is well to regard the radiator and fan together; moreover, the power of the fan will make a large difference in the core depth. Just what conclusions to draw on this phase of the subject the author is at a loss to know. It would seem that a 4-in. core was too deep for greatest efficiency, and this has at various times proved to be the case. Yet upon some tests conducted on two different makes of radiators the 3⅞-in. core proved to have greater capacity than the 3⅜-in. core.

As a practical suggestion to car builders, the author offers that every purchaser be furnished a special card cautioning him to keep the exterior of the radiator as clean as he possibly can. Much heating complaint would be avoided if radiators were kept clean. Tests go to prove that when a film of oil gathers enough road dust the radiator efficiency becomes about one-quarter normal.

SELECTING THE FAN

Researches made by radiator manufacturers have shown that cooling varies directly with the quantity of air passed through the radiator, other conditions being uniform. It has, therefore, been the long-time hope of many of the radiator manufacturers that an improvement be made in fans.

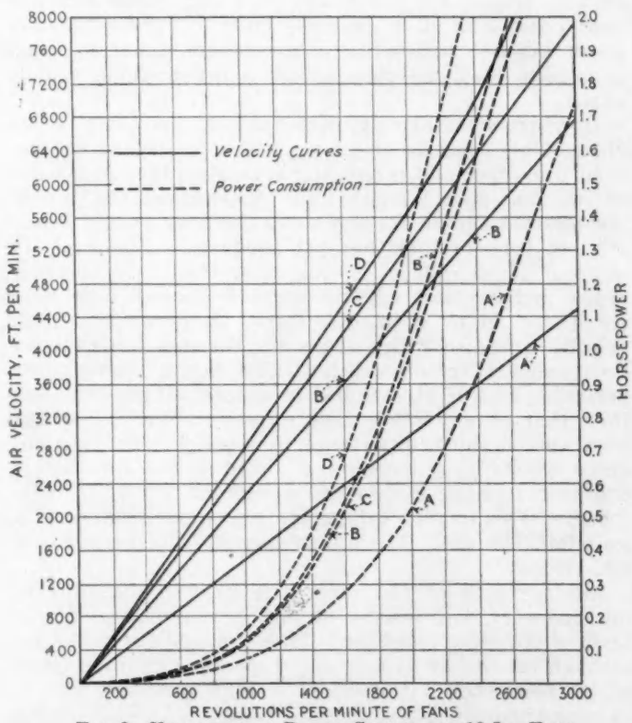


FIG. 2—VELOCITY AND POWER CURVES FOR 18-IN. FANS
Curve *A*—Four-blade fan (flat blades). Curve *B*—Three-arm multi-blade. Curve *C*—Five-arm multi-blade (special). Curve *D*—Five-arm multi-blade (standard)

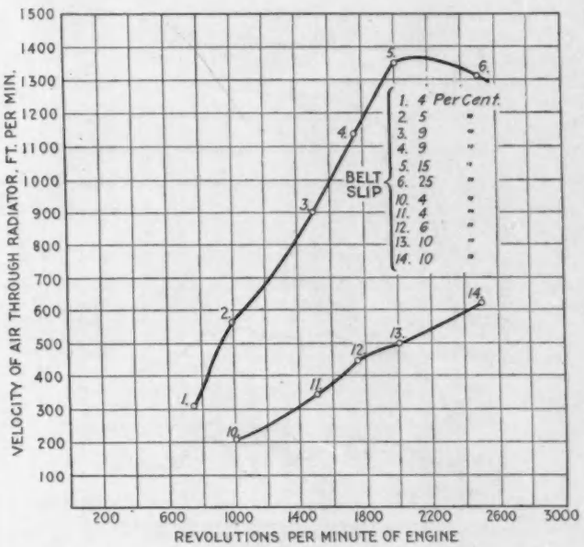


FIG. 1—AIR DELIVERED BY FANS AT DIFFERENT ENGINE SPEEDS
Curve *A*—Three-arm multi-blade fan; diameter, 16 in. Curve *B*—Two-blade (curved blades); diameter, 17 in.
Fan speed, 1½ engine speed. Pulleys, 3 by 1 in.; belts, ¾ in. flat.

Experiments conducted by the writer (see Figs. 1 to 5) have confirmed the theory that cooling varies directly with the quantity of air drawn through a radiator.

Some engineers place little stress upon the value of air as a cooling agent, except within very wide latitude. They apparently are of the belief that it requires a large increase in air delivery, say 300 or 400 per cent, to make any noticeable improvement in the cooling apparatus as a whole.

In contravention to this argument it need simply be pointed out that a certain time-honored practice among some engine builders proves that the contrary is the case. When engines are placed upon the dynamometers to be "run in" they are usually connected with their standard radiators, and carry their regular fans. Experience showed in some cases that this did not provide sufficient cooling to make safe running, so the simple expedient of placing an electric fan on a bench in front of the radiator and directing its air current into the radiator is resorted to with satisfactory results.

First and foremost in the selection of a fan should be considered the element of quantity of air delivery. The ideal radiator, as has been stated, is the one that will give off its heat at such a rate that the air that passes out of it can absorb no further heat units. In combination with this radiator the ideal fan is the one which will draw air through the radiator at such a high velocity that the air undergoes no measurable increase in temperature as it passes through.

The rate of heat transmission from one medium to another is directly proportional to the difference in the temperatures between the two mediums. This rule applies exactly between all the variations met with in automobile practice. Therefore, the efficiency of a radiator and fan system combined would be greatest when the mean temperature of the air passing through the radiator were lowest; or, in other words, when the difference in temperature of the water in the radiator and the air passing through it were greatest.

As an illustration, assume the case of a radiator on a summer day, with atmospheric temperature of 85 deg., mean water temperature of 200 deg., and a rise in temperature of air passing through the radiator of 50 deg.

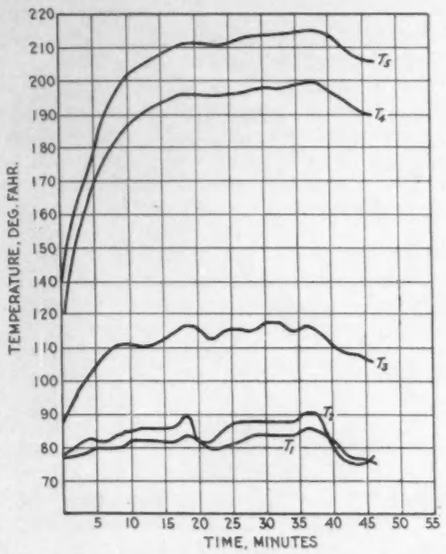


FIG. 3—VARIATIONS OF AIR AND WATER TEMPERATURES

T_1—Free air in room. T_2—Air entering radiator (4 in. from face). T_3—Air leaving radiator (¼ in. away). T_4—Water at pump. T_5—Water in top of radiator

Fan, five-arm multi-blade; diameter, 18 in. Engine speed, 1010 r.p.m. Fan speed, 1610 r.p.m. (3.4 per cent belt slip). Load on dynamometer, 12.6 hp. Velocity of air through fan, 1300 ft. per min. Radiator, diamond pattern. Belt, built-up V-type.

The mean air temperature through the radiator is, therefore, 85 + 50/2 = 110 deg. and the differential between the water and air is 90 deg. Heat will be transmitted in its proper ratio to this differential.

Take, then, the case when all other conditions are the same as in the foregoing case, but increase the air velocity 40 per cent, and thereby reduce the temperature rise from 50 to 30 deg. The mean air temperature through the radiator then is 85 + 30/2 = 100 deg., and the differential becomes 100 deg. Heat will be transmitted at a faster rate in the proportion of 100 to 90, or an increase of 11 per cent.

The foregoing demonstrates that if one fan has twice the capacity of another it does not follow that a 100 per cent increase in the engine-load capacity can be looked for.

As a matter of practice, then, the rule can be set down that the fan is of vital importance, and that the best fan obtainable should be installed. The question that follows is, What is the best fan obtainable? The answer to this is the fan that on any limit of diameter will give the maximum air velocity per revolution is the best fan.

Air velocity depends upon a fan's ability to build up pressure, and pressure overcomes the normal friction in the radiator and drives the air through at a velocity proportional to the square root of the pressure.

Fans of any one design increase their capacities in approximately geometric progression with the increase in diameter. Best practice would therefore suggest the use of the largest diameter possible on any particular model of car.

Classification of Fans

There are several distinct types of fans offered by the various manufacturers, classified for description as follows: Rim fans, which are those whose periphery is bound by a circular rim; flat-blade fans, which are usually of three or four flat blades built out from a central spider; curved-blade fans, which are similar in construction to the flat-blade fans, except that the blades are curved somewhat after the manner of a garden trowel; and multi-blade fans, which are of two or more arms, up to six, and in which each arm consists of two or more blades.

Taking them in the order named, we note two types of rim fans, namely, those having a thin rim almost like a wire, and those having a broad rim equal in width to the sweep clearance of the blades. In the former type, as nearly as the author can ascertain, the rim is supposed to add strength in the resistance both to centrifugal force and to bending. It is also intended to act somewhat as a safeguard to the radiator, should the fan become bent or out of line and strike the radiator. In the latter type of rim fans it appears that the intention is to reduce noise.

The author has conducted air-delivery tests extensively on both types of rim fans and has found them very inefficient.

Flat-blade fans are the most common in use at the present day. They are usually of the four-blade type, built upon a central spider. Their air-delivering qualities are not good at low speeds, say at a peripheral speed less than 5000 ft. per minute, consequently they have to be run at very high speeds. High-speed fans are noisy, and consume a large amount of power. These two factors will be discussed later in this paper. It is safe to say that the flat-blade fans are very efficient when working at peripheral speeds in excess of 15,000 ft. per minute, which for 16 and 18-in. fans is close to 3000 r.p.m.

Curved-blade fans, as a class, are similar in their construction to flat-blade fans; that is to say, they are normally built up on a central spider and are of three or four-blade design, generally. In capacity and efficiency they are much ahead of the flat-blade and rim fans for automobile use. Of course, they do not show a constantly increasing efficiency at very high speeds, 4000 and 5000 r.p.m., but then good engineering practice would counsel against the use of any such fan speeds where it were possible at all to get away from it. These fans are good because their efficient speeds are generally comparatively low, and they handle a considerable volume of air.

Only one multi-blade type of fan is at present in existence. This consists of groups of blades placed one behind the other, and presenting somewhat the appearance of two fans upon a single hub. Experiment has demonstrated that this is far and away the most powerful and efficient type of disk fan yet produced. The capacity is from 50 to 100 per cent greater than that of other types, and its most efficient speed is from 800 to 1200 r.p.m. for 16 to 20-in. diameters. It develops a high velocity pressure which drags air through the radiator even under adverse conditions. Its power consumption per cubic foot of air handled is at least 40 per cent less than that of any other type of automobile fan it has been the author's experience to test. It also has another quality that recommends itself to the automobile engineer, namely, it develops a high suction at its periphery. This quality brings the edges and corners of a radiator into use. The advantages of this feature are self-evident.

Another type of fan very little used in the automobile industry, but worthy of notice in a paper of this kind, is the centrifugal fan. This is a fan that takes air through the line of its axis and discharges it in the plane of its perimeter. It develops a high pressure, but is of comparatively low volumetric capacity. On air-cooled engines it has been found satisfactory, but its adaptability to water-cooled systems remains to be worked out.

The engineer, in making his selection of a fan, should take into serious consideration the amount of power necessary to handle maximum air velocities through the radiator. This phase of the question has been considered by very few engineers. A study of the accompanying power curves will show that an astonishing amount of power can be used by a fan when its speeds are excessive.

Fan Power-Consumption and Speed

Take, for example, the 18-in. fans for which the power, speed and air delivery are plotted. At 1000 r.p.m. the flat-blade fan was delivering a velocity in free air of 1423 ft. per minute on a power consumption of 0.077 hp.

The multi-blade (five-arm) fan, at 1000 r.p.m., was delivering air at a velocity of 2580 ft. per minute on a power consumption of 0.18 hp. under the same conditions.

Now compare this with what took place at double the speed (2000 r.p.m.). The flat-blade fan handled air at 2826 ft. per minute velocity and consumed 0.524 hp., and the multi-blade fan generated a velocity of 6060 ft. per minute and consumed 1.4 hp.

The increase in power, it will be noted, was almost in direct proportion to the cube of the speeds.

Many engines are so geared that the fans at times are supposed to be making as many as 4500 r.p.m., and the power consumption theoretically increases to 6 or 8 hp. It is the author's contention that such a power expended on driving a fan is completely wrong, and that its practice should be discontinued without delay. Engines running up steep hills or through heavy roads are frequently shifted into low gear in order to let the cylinders do the work possible at high piston speed. Under such circumstances, then, the fan is demanding one-sixth to one-eighth of the engine's power. This 6 or 8 hp. generates its quota of heat, which again has to be extracted. It is a good fan that will assume this additional burden without allowing boiling.

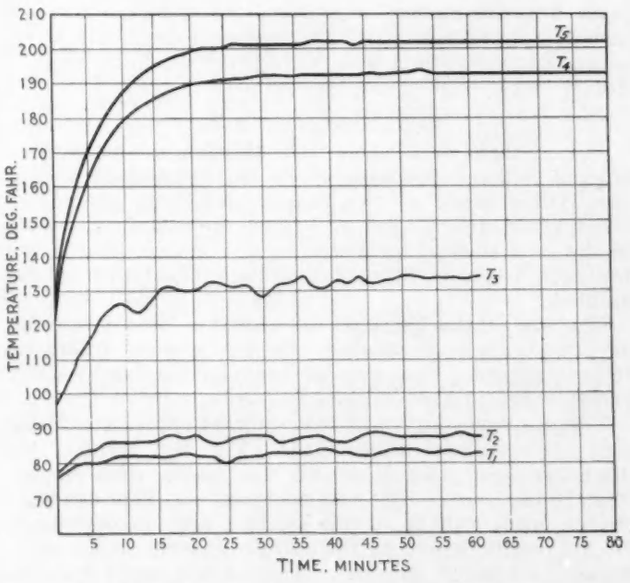


FIG. 4—VARIATIONS OF AIR AND WATER TEMPERATURES

T_1—Free air in room. T_2—Air entering radiator (4 in. from face). T_3—Air leaving radiator (¼ in. away). T_4—Water at pump. T_5—Water in top of radiator

Fan, five-arm multi-blade (std.). Diameter, 18 in. Engine speed, 998 r.p.m. Fan speed, 1591 r.p.m. (3.4 per cent belt slip). Load on dynamometer, 12.5 hp.. Velocity of air through radiator, 887 ft. per min. Belt, built-up V-type. Radiator, square air tube, 3¼ in. core.

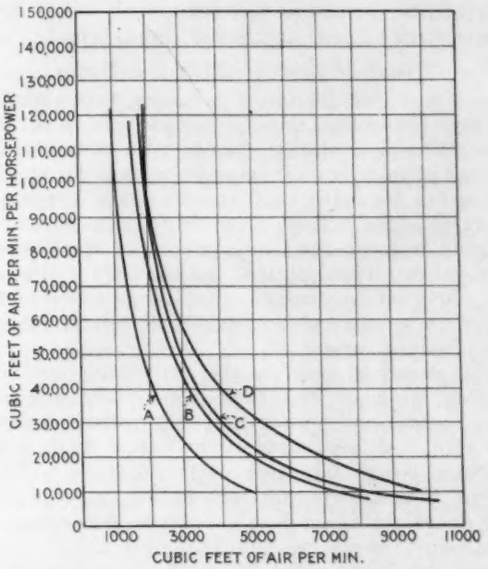


FIG. 5—RELATION OF HORSEPOWER AND FREE AIR DISCHARGED BY 18-IN. FANS

Curve *A*—Four-blade fan (flat blades). *B*—Three-arm multi-blade. *C*—Five-arm multi-blade (standard). *D*—Five-arm multi-blade (special)

Fan Belts and Pulleys

In looking at the situation from a practical standpoint we must investigate the medium through which this high power reaches the fan. This transmission is usually through either a flat or V belt. Can a leather or canvas belt, whose contact width is between ¾ and 1¼ in., transmit much over 3 hp.? The best authorities on the subject say it cannot be done. This answer is probably correct.

Many pulleys in use are too small in diameter. While theoretically pulley diameter has no effect whatever on power delivery, it does have a material effect on belt slip, and consequently upon fan speed. Much fan trouble arises from this cause.

The experience of belt makers shows that a pulley should never be of a diameter less than 30 times the thickness of the belt. This is practically out of the question in most automobile designs, as it would necessitate a 4-in. pulley. However, the fault of going to the other extreme and using a pulley 1½ to 2 in. diameter should be corrected, and must be before the automobile manufacturer can feel assured of getting the designed performance from fans. A minimum diameter of 3 in. is earnestly recommended.

Much remains to be done in selecting belts, and from recent reports it appears that some types of V belts are giving superior service.

Experiments conducted by the author demonstrated that with a 1-in. flat belt a 15-in. fan could not be driven at a speed greater than 3200 r.p.m. without a large percentage (over 30) of slip, which soon proved destructive to the belt.

The summary of the whole situation, then, is that when the engine gets beyond a certain speed, so that the fan makes 4000 r.p.m. or over, the belt begins to slip, and once this condition has set in the fan becomes worse than useless. A slipping belt does itself much harm,

and in addition polishes the fan pulley so as to make the percentage of slip at normal speeds greater.

Disadvantages of High Fan-Speed

Several hundred thousand cars are built annually in which fans are so connected as to develop a speed of from 2000 to 2500 r.p.m. when the car speed is 20 m.p.h. These cars, most of them, do not show a tendency for the engine to heat when traveling over smooth roads at that speed, but they do when making from 30 to 40 m.p.h., or when the engine is doing the same amount of work in one of the low gears. Then, at just the time when the cooling agents are most in demand, the fan is either slipping, or using an amount of power not at all commensurate with its cooling power.

In fan practice, both in the ventilating and in the automobile trade, it has been pretty well proved that all fans become noisy when their tip speeds exceed 5000 ft. per min. At any speed beyond that there is bound to be noise, which increases with the speed. When 16 and 18-in. fans are running at 2000 r.p.m. or more they are far above the silent-zone speed. In many cases they produce sounds much resembling a sawmill.

When a car is racing at 35 or 45 m.p.h. the driver is too busy to notice the objectionable noises, but when the same car rolls down a smooth city boulevard at 20 m.p.h., and all of the other mechanisms are practically noiseless, it is somewhat incongruous to have a little 2 or 3-lb. fan making all the fuss.

The demand from engineers who build our standard cars is daily becoming more insistent for less noise from the fan. The only way for this demand to be met is to bring the fan speeds down to somewhere within reasonable limits.

The apparent obstacle to meeting this demand successfully is the fact that, generally speaking, fans in use today will not deliver much air until they are buzzing at tip speeds of about 10,000 ft. per min. It is to be hoped that automobile engineers will make fan builders produce better fans.

Everything points to the necessity of reducing the fan speed; wear on bearings and belts, noiseless operation, and, most of all, conservation of power, demand fans that can deliver the air at lower speeds. In short, we must have better fans.

Types of Fan Bearings

Bearings are of several distinct designs: the plain iron or steel bearing, similar to an ordinary wagon wheel on its axle; the bronze bushing on the steel spindle; the cup-and-cone ball bearing; the roller bearing; and finally the annular bearing.

The iron hub or steel spindle bearing satisfies the demand for a low-priced bearing. It gives satisfaction of a certain kind, but it is subject to and does have so many troubles that it really should not be used

The bronze bushing on the steel spindle is good enough in its way, but it costs real money when properly made, and has a tendency to let its lubricant run out at both ends and spatter things with grease. The saving in cost over one of the types of roller bearings is so little as to make it hardly worth while.

The cup-and-cone ball bearing has been the most widely used of the so-called "better bearings."

The author has never been able to comprehend just how this type became so popular since its basic principles are wrong for most fan applications. For shafts or spindles that present a uniform vertical thrust the balls take the load in a normal line because their obliquity to the axial line is compensated for by the opposition of one set to the other. Such is the case in motorcycle and bicycle axles. The belt on fans exerts a heavy downward pull, usually from the line half way between the cups and the fan, then exerts a thrust at right angles to the belt pull. The whole arrangement, therefore, seems wrong.

The cup and cone bearings apparently are always looking for trouble. As a matter of fact, a good cup and cone bearing ought to be the most expensive kind to make, but again the element of reduction in first cost has influenced conditions to a point where the greatest criticism that can be made is of the quality of the materials used.

The annular bearing is the ideal for those who are willing to spend the money for quality. Good annular bearings cause no trouble and good ones can be found. They are noiseless, and reduce friction to a minimum. They can also take up the thrust without the interposing of thrust washers. The automobile engineer should, however, look out for cheap imitations as there is a wide difference in quality among the many makes of annular bearings. The best that can be had is none too good.

Roller bearings of several types have been offered for fan use. The application of these on fans has been comparatively limited, but there will be a decided increase in their use during the next year. One make in particular has stood the test of continuous running and meets the price qualifications within reasonable limits. It consists of a series of helical steel rollers held in place by two end disk washers. The latter are rigidly held in their planes by small rods that also serve as spacers between the rollers. The whole presents the form of a hollow cylinder 2 in. long. This is placed over a carefully machined steel spindle. Into the pulley hub is inserted a seamless or split steel sleeve that acts as an outer path for the rollers while the steel spindle is the inner path.

It is earnestly recommended that this subject be considered by the Society with a view to standardizing one or two types of bearings. The engineers could then write uniform specifications and fan makers would be free to devote more effort to the fans proper.

APPLICATIONS OF FANS

Taken, then, as a whole unit, the fan should be considered with all the care given any other part of the car. Other parts of the chassis and body should be constructed with a view of letting the fan do its work in the most efficient manner. Assuming, now, that a fan has been selected, the nature of its application must be studied.

The air intake through the radiator should present as little friction as possible; there is a wide difference in this respect. The distance between the fan and the radiator should always be ½ in.

The air "getaway" will bear much improvement, and such improvement can be made. For best results, the discharge area should exceed the intake area by at least 20 per cent. This rule assumes, also, that the discharge space will be in one location and unobstructed. No automobile known to the author presents such a condition. Moreover, in every car thus far measured, the discharge areas are less than the free radiator supply area.

Spaces under the dash are hard to alter, but plenty of louvers can be inserted in the hood, and these should be figured as the primary means of air escape. Why the car designer objects to louvers is not altogether clear, but their necessity is so great that appearance can well be sacrificed.

The air passing through a radiator expands a great deal under the hood. With an inadequate escape area, the static pressure builds up to a point beyond the fan capacity and relieves itself by backing out through the radiator.

To overcome this, shrouds have been placed around fans in some cars. The effect is then to increase the air distribution over the front of the radiator, but the shrouds are inefficient because of the sharp angle they necessarily make with the rear face of the radiator; furthermore, they cannot increase the capacity of the fan.

The air velocity will be greater than it was through the deep radiator because the friction has been reduced. Thus the fan has even more than compensated for the reduction in core.

METHODS OF CONDUCTING FAN TESTS

Up to the present time, automobile engineers have been so busy with the other more complicated phases of their work, that few have had the opportunity of familiarizing themselves with the rather whimsical behavior of air and fans. Consequently opinions are so diverse as to what shall be done to test a fan properly that much time is lost and the results obtained are not always satisfactory to either the engineer or the fan manufacturer.

As the S. A. E. has never adopted a standard method of conducting fan tests, the author offers the following methods for consideration.

Test No. 1.—Place the fan on the shaft of a sensitive dynamometer equipped with the means of reading speed and power consumption. The fan should be at least a full diameter away from any obstructions in its rear, should have a 10-ft. clear discharge space ahead, and should have at least a quarter-diameter clearance between the table or bench and its peripheral circle. In front of the fan, at a distance of from 3 to 6 in. clear of the blades, a light wire frame of small squares should be placed so as to divide the area into any desired number of parts in order to obtain uniform air-delivery readings.

The fan should then be run at speeds from 500 to 4500 r.p.m., and the air delivery and power consumption recorded for each speed.

Many engineers use the anemometer for measuring air velocity, but experience has shown that this instrument is not reliable for registering the high velocities at the face of a disk fan. It is subject to practically imperceptible, though serious damage during tests and thus may give rise to erroneous results.

The pitot tube is by far the most accurate instrument for measuring fluid motion, and is sensitive to low as well as high velocities. Furthermore, it cannot be readily damaged without being immediately observed, consequently the accuracy of its readings can be relied upon.

The results of this test will be a free-air calibration of the fan and thus a standard with which tests under other conditions can be compared and checked.

Test No. 2.—Connect the gas engine whose cooling device is to be tested to a high power dynamometer. Attach the fan to the engine in its standard manner and also set up a radiator, properly connected. Put in place the hood, sod pans, etc., so that the entire set-up will resemble the forward part of the car.

Place laboratory thermometers in such a way that the following temperatures can be recorded:

Air in room.

Air entering radiator.

Air leaving radiator.

Water in top of radiator.

Water entering jacket.

Keep an accurate count of the revolutions made by the fan. This is very important.

Run the engine under light load, over a range of speeds corresponding to the travel of a car at rates of from 15 m.p.h. to 50 or 60 m.p.h. Six or seven such readings will usually suffice. At each speed take a set of readings in front of the radiator for air velocity through the radiator. It will be found an aid to accuracy if the radiator is divided into say 16 squares by chalk marks.

By this method a complete record of air delivery through a radiator is obtained. This test throws the entire burden of air delivery upon the fan, as no assistance is derived from forward motion of the car or from wind.

The pitot tube will be found especially valuable for this kind of test as the detailed behavior of the air can be so clearly observed.

Temperature readings can be taken during all these runs, but are not necessary as they are provided for in the next test.

Test No. 3.—With all apparatus set up as for Test No. 2, select speed, load and conditions of spark and throttle levers at which heating may be looked for. Impose these conditions and take temperature observations at intervals of about two minutes. Continue this until the water boils or until the water temperature in the top of the radiator remains uniform for ten or twelve minutes. The fan speed should be constantly checked for slip of belt.

Test No. 4.—Road tests may be run finally to check all results against those obtained in the laboratory. It will be found difficult, however, to obtain conditions fit for such tests over public highways generally, owing to the speed laws, other vehicles on the road and the general poor condition of roads over a long stretch. If a good road up a hill can be found, excellent data should be obtainable.

A positive and reliable revolution counter should be placed on the fan so that the same checks may be had as in the laboratory tests. This is even more important than indoors, because the car motion over the rough spots will be found to jolt the fan bracket loose at times. A thermometer (not a radiator heat indicator) should be secured in the filler cap of the radiator, and one should be lashed to the frame work of the car body to register atmospheric temperature. Temperatures of the other parts of the cooling system cannot be obtained in road tests without resorting to the use of elaborate apparatus such as thermoelectric couples and recording thermometers, and even then the results are likely to be erroneous, because of car motion over rough spots.

The spark and throttle quadrants should be marked so that the levers can be reset to the positions used on a previous run, if desired.

Measured distances at known speeds should then be run and time and temperature records kept.

A full description of all apparatus used, together with the essential dimensions of the engine, the radiator, the fans, the gear ratios, etc., should accompany the report of every test.

THE DISCUSSION

GEO. W. SMITH, JR.:—Why are multi-blade fans more efficient?

A. K. SCHANZE:—As a fan blade travels through the

air it creates a slight wave ahead of it. The leading blade on the multi-blade fan handles the air in the same manner that the blade on the single blade fan does. The second blade comes along and picks up a certain amount of the bow wave that is lost by the leading blade and creates a higher compression between the two blades than would be gotten on the single blade.

MR. SWITZER:—Is it not a fact that the efficiency depends on the distance between the blades?

A. K. SCHANZE:—If the blades are too close together the efficiency is zero and the energy is wasted. They have to be sufficiently far apart to allow the following blade to pick up all the air that it would if it were free. The multi-blade fan cannot work at as high a speed as the single blade fan. A multi-blade fan takes per revolution more power to turn it. Its operating efficiency does not decrease until about 4000 r.p.m.; beyond that it will fall somewhat in the same manner that a single blade fan will when it gets up to 6000 to 7000 r.p.m.

J. V. WHITBECK:—Can the multi-blade fan be run at lower speeds and does it consume less power than the single-blade fan?

A. K. SCHANZE:—The efficiency of the fan is such that the power used by the multi-blade fan is much less. We make this basic contention; that, for any given number of revolutions or for any speed, the fan will handle at least 50 per cent more air than any other fan, or that for any volume of air it will do the work with 40 per cent less power.

A MEMBER:—If the capacity of a single-blade fan is increased, the resistance is such that the exhaust air cannot be disposed of; the higher efficiency fan would show similar results because the resistance is so great.

A. K. SCHANZE:—If the passage is not there for the exhaust, naturally the force applied at the front of the fan will act opposite. Handling air on a car is a difficult problem. A certain size of propeller has to be a certain diameter; otherwise a churning of the waves is produced. Propellers can be operated at an efficiency of 98 per cent if run at from 1200 to 1400 r.p.m., but the air must have clear passage. The difficulty is in placing the propeller at the proper distance.

S. JENCICK:—It may be possible that the multi-blade fan is too efficient and compresses the air to such an extent inside the hood that the back pressure prevents sufficient air from going through the radiator. The back pressure near the front cylinder, which is the greatest obstruction to the air current, is sufficient to prevent the radiator cores furnishing air. Of course, if the air does not pass through the radiator it cannot cool the water. The single-blade type of fan will handle only an amount of air that will pass readily beside the engine and over it and under the floorboards, whereas the multi-blade fan may be so efficient that it compresses the air to a degree that destroys its own efficiency.

A. K. SCHANZE:—The proper thing then is to reduce the speed of the multi-blade fan on the car so that it will do the same work that was done by the other fan at a greatly reduced power consumption.

FREMONT TRACTOR MEETING OF THE SOCIETY

AN S. A. E. Tractor Meeting will be held at Fremont, Neb., Wednesday and Thursday, Aug. 8 and 9, during the National Tractor Farming Demonstration, which starts Monday, Aug. 6, and lasts all the week. More than 250 different types and sizes of tractors will be engaged in plowing and other farming work, so that members of this Society who will attend the meeting will have an unusual opportunity to observe the tractors in operation.

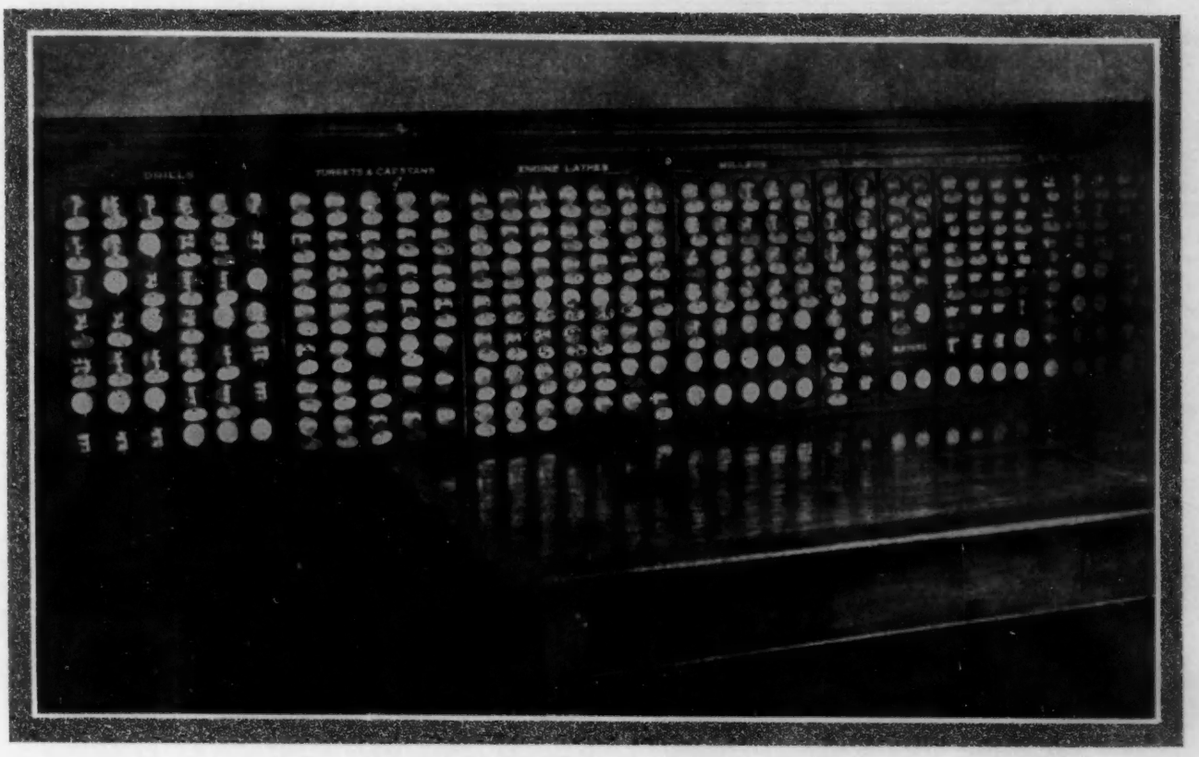
The S. A. E. Headquarters will be on the mezzanine floor of the Hotel Pathfinder, Fremont. All members should register at Headquarters. The demonstration is held on the Lincoln Highway, about two miles out of Fremont; a jitney service will be available at all hours. On Wednesday evening, Aug. 8, an S. A. E. dinner will be held at the Masonic Hall, Fremont, for which tickets, at $1.50 per plate, can be secured from the office of the Society. The dinner will be followed by technical papers given by prominent authorities. Arnold P. Yerkes of the Agricultural Department at Washington will give a paper, The Tractor From a Farm Management Viewpoint.

The possibilities of using kerosene instead of gasoline for tractor engines will be considered. Mr. Clarke, chief engineer of the Wilcox-Bennett Company, will give an address on the methods of obtaining satisfactory operation when kerosene is used for fuel. A number of representatives of refiners and others interested in the tractor-engine fuel problem will take part in the discussion.

On the evening of the 9th the meeting at Masonic Hall will be devoted to service-tractor problems. Dent Parrett will give a paper on the subject. Fred C. Glover, L. B. Duntley, H. C. Merritt, and other prominent tractor men, will take part in the discussion. It is believed that the farmer, dealer and manufacturer will derive benefit from the broad standardization of tractor parts used in common in many different tractors. Fewer spare parts will be needed, and it will be easier to secure them in case of emergency. In this respect the service problem is intimately related to the work planned by the Tractor Standards Division. This work will receive full consideration at the Service Session.

An open meeting of the Tractor Division of the S. A. E. Standards Committee will be held Aug. 8 at 9.30 a. m. in Masonic Hall, Fremont. The Tractor Division has already made a start in the work, but it is regarded of fundamental importance to settle on a number of additional standards, particularly because of the large increase in tractor production necessary for increasing the food supply.

It is an easy matter to reach Fremont, which is a town of about 10,000 people just 40 minutes west of Omaha, on the Union Pacific. The railroad accommodations are good, as there are 45 trains each day. The Tractor Farming Demonstration is being conducted by the National Power Farming Demonstration Association under the auspices of Fremont Commercial Club, a local organization composed of a large number of prominent and public-spirited citizens. Last year a number of similar demonstrations were held, but this year the only one will be at Fremont, which is in the heart of one of the richest grain-producing districts of the country.



Board Used for Machine Capacity Records

Notes On Works Organization

THIS paper, presented at the May meeting of the Institution of Automobile Engineers, outlines an organization scheme designed for an English factory manufacturing automobiles. Charts are given showing the duties assigned to each department of the plant. Samples of the various forms are reproduced and the methods followed in applying these forms to actual production are described. The paper is given in accordance with the policy of the JOURNAL of reprinting important engineering articles.

By A. W. REEVES *and* CECIL KIMBLER *Illustrated with* CHARTS AND PHOTOGRAPHS

THE organization of an engineering works does not as a rule arouse marked enthusiasm in the mind of the technical enthusiast, for to such a man routine work, largely of a clerical nature, is by no means attractive. Nevertheless, private engineering enterprises have obviously a short life unless they are conducted in such a manner that financial profit accrues.

In other words, engineering concerns are perforce required to be run as commercial propositions, and whether the technical enthusiast likes it or not, he is compelled to consider his projects as much from the financial as from the purely technical standpoint.

After a great deal of cancelling out it is inevitably found that, other things being equal, the most essential feature to insure financial success is "output"; overhead charges, of course, vary inversely with the output.

It may be stated that a business organization is a set of laws so framed as to provide an orderly method of directing the business energies of a company in a manner similar to that whereby a country is provided with laws that order the lives and activities of its citizens.

The most successful country is generally admitted to be the one with the most really successful laws; it therefore follows that the success of a business depends upon the laws or organization by which it is managed. Modern conditions demand that more and more attention should be paid to the organization or method in which the business is conducted, and it applies as much to the internal as to the external conduct of the business. The former takes care of the production of the article, the latter takes care of its sale.

The following matter is descriptive of rules and regulations framed with the object of guiding the energies of the executive and the operators concerned in the production of an engineering commodity. Technical points are not dealt with at all.

Little may be said respecting the manufacturing policy adopted by the directors of the business concerned. It is assumed, however, that (by way of a change from what usually exists in so many British engineering works, including automobile factories) the controlling directors have really made up their minds what it is they wish to manufacture, what capital they are prepared to put at the disposal of the company for that manufacture, and what quantity of the articles in question are to be manufactured over a given period. If these main essentials

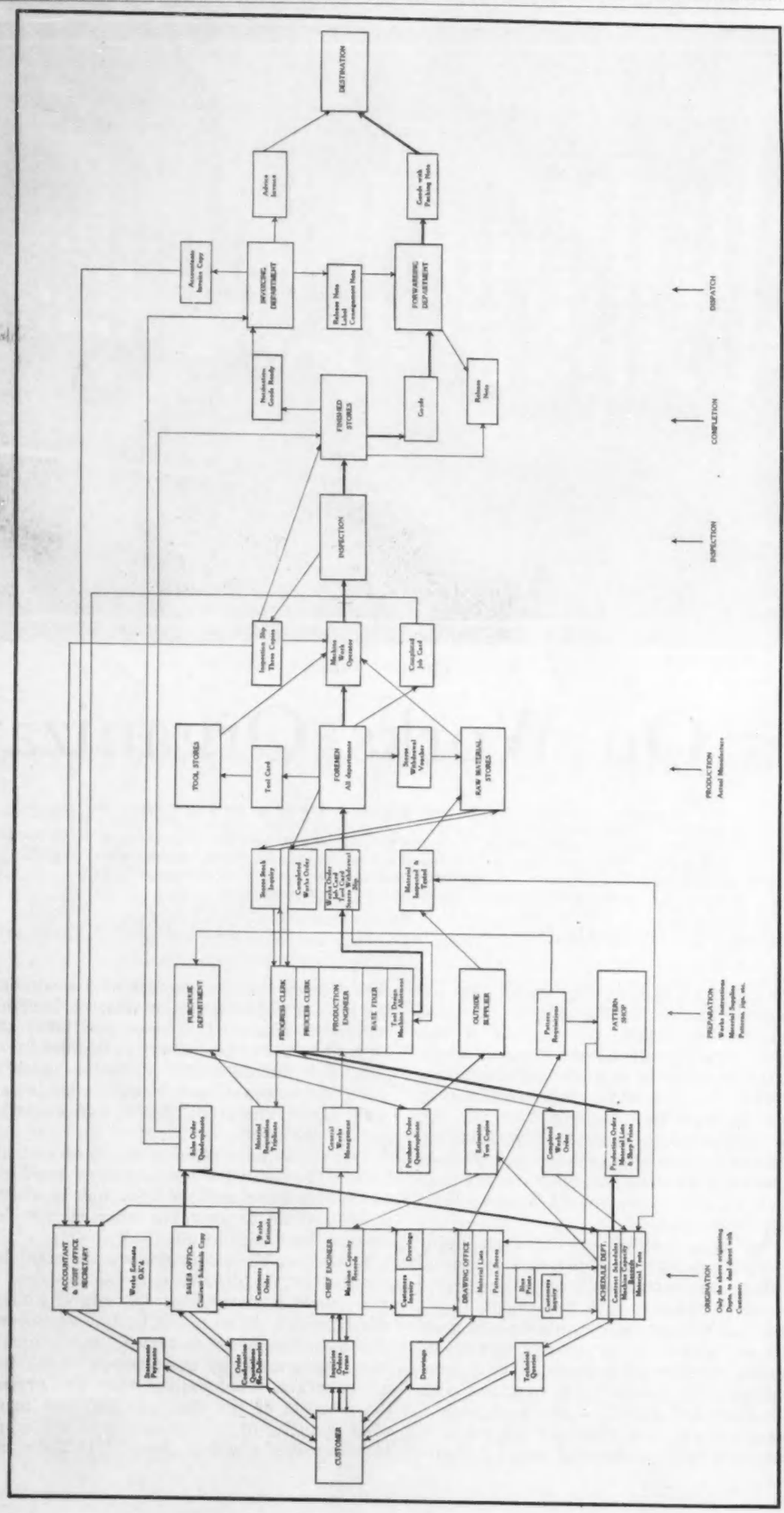


FIG. 1—KEY PLAN OF ALL DEPARTMENTS. WORKS ROUTINE AS AFFECTING CONTRACTS. MAIN ROUTINE IS INDICATED BY HEAVY LINES. INCIDENTAL ROUTINE BY LIGHT LINES. ARROWS SHOW DIRECTION OF MOVEMENT OF FORMS AND THEREFORE OF OPERATIONS

are not definite and the directors of the company have variable ideas concerning them, it would be far better not to commence on the manufacturing scheme at all.

The authors personally doubt whether better methods of organization have altogether been the cause of much of the so-called German industrial success—it may be very seriously asked whether it is not more due to the German national characteristic of fixity of purpose. The German has a solid temperament. He thinks for a long time what it is he is aiming at, and, having decided, he goes more or less straight for it.

The matter of the general layout of the plant is not considered here, but in the authors' opinion the time-honored layout whereby the various *types* of machines are collected together and put in their own special section is altogether wrong. The authors' principle is not to collect *groups of like machines*, but, what is quite different, to collect *groups of machines necessary for the production of a particular component* or group of small components. For example, in the case of automobile manufacturing the idea is to collect in one section all the machines necessary to produce gear boxes, while in another section would be collected machines necessary to produce front axles. The manufacturing policy as to quantity production has, of course, a great bearing on this matter.

On this subject the manufacture of munitions of war has taught us a great deal. In fact, the motor vehicle manufacturer, for example, who, owing to war orders, has been able to remain entirely employed on his pre-war product, is perhaps to be pitied. He has lost some of the most valuable experience possible, and the authors assert that automobile factories which have had to turn over to the production of munitions, will, after the war, and as the result of their experiences, be in a most favorable position for competition. The experience will have been a blessing in disguise.

When the matter of works organization comes to be thoroughly investigated, it is seen that there are certain broad principles to be followed and applied, no matter what the nature of the manufacture. This broad outlook is narrowed when the particulars come to be applied to the engineering trade, and the authors put forward the following manufacturing system or scheme in the certainty that, with slight modifications, it can be adapted to practically any present-day engineering works. It was designed for a works previously engaged on automobile manufacture, but now, owing to the war, converted into what might be termed a general engineering shop. Its principles, however, apply equally well to a specialized output.

One of the essentials of a works routine is the reduction of documents—and consequent clerical labor—to a minimum, and with this end in view it is essential that the secretarial side of the business should be in full sympathy with the works and shop management.

By use of the authors' diagrams, it is possible for all departments to know exactly the extent and scope of their respective duties. This, coupled with a key plan, makes every man conversant with his own duties as well as with those of others.

In so many works it is found that each department is a community to itself, each having its own methods of carrying out its work, but the whole lacking that smoothness of working and coordination that is so essential.

It will be seen, therefore, that organization consists in the dove-tailing of the work of one department into that of another, in order to produce the greatest efficiency for the *whole*, although this dovetailing *may* possibly reduce the effectiveness of an *individual* department.

BROAD OUTLINE OF ORGANIZATION

Taking the average works, it will be found that the departments can be divided into five main groups or sections, designated on the authors' key plan (Fig. 1) under the titles, "Origination," "Preparation," "Production," "Inspection," and "Despatch." These apply only as far as the execution of a contract is concerned, but this is, after all, the main thing for which the organization is planned. It will be seen that the departments coming under the heading of "Origination" comprise the Chief Engineer and the Sales, Accounts, Drawing Office, and Schedule (and Estimating) Departments. These Departments are the only ones to correspond *directly* with the customer, and it is from these departments that the order "to produce" is issued to the works. Hence the term "Origination."

Under "Preparation" we get the various sub-departments controlled by the Works Superintendent. These sub-departments prepare the order, design the tools, jigs, etc., ready for issue to the shop. Thus everything is "planned out" ahead before actual production is commenced. See Fig. 11.

Under "Production" there is, of course, the shop foreman, and the actual operators and machines, whose work has been previously mapped out to the smallest details by experts in the planning department.

Inspection and despatch are self-explanatory.—Fig 10.

As far as possible, unforeseen circumstances, that dread enemy of organization, have been provided for. The idea is for each department to have a copy of the key plan, and a departmental plan prominently displayed in each office, in order that everyone concerned may be thoroughly conversant with the routine. In the case of certain works forms, of which several copies may be issued, each with a different, but vitally necessary, destination, the departmental plans can be supplemented with wall copies of "Document Route Charts" as shown in Fig. 2. In addition to this, plainly worded instructions should be printed on the back of every works form as to the correct procedure to follow. In this manner the training of a new staff, in the event of changes, is reduced to a minimum.

This latter is really a bigger point than many employers and executives imagine, but there must be many members who, especially since the War started, have had the heartbreaking work of drilling and instructing an entirely new and raw staff in the current system of an established works organization. Above all must simplicity be aimed at in the sub-division of duties and the "unknown contingencies" be guarded against as much as possible.

An important factor to the authors' mind, and one that appears to be entirely ignored in the wonderful works systems originating on the other side of the Atlantic, and among many idealists on this side, is that of the personal or human element. Anyone with any knowledge of the independent and, it must be confessed, "awkward" spirit characterizing the workers of, say, the Northern Midlands, would hesitate before applying the extreme methods of the latest American "Scientific Management," well knowing the futility of the task. On the other hand, in hundreds of engineering shops up and down the country the productive capacity could be vastly increased if better organization were to displace the old rule-of-thumb method, or reliance on outstanding personalities.

The authors believe, however, that these reforms will have to be introduced gradually and that the "extremist" reformers will gain no sympathy or success. Above all, beware of the professional business organizer. Therefore, do not make the mistake of starting with too ambitious a scheme. Decide on broad and sound principles to be followed first, and let the rest grow gradually.

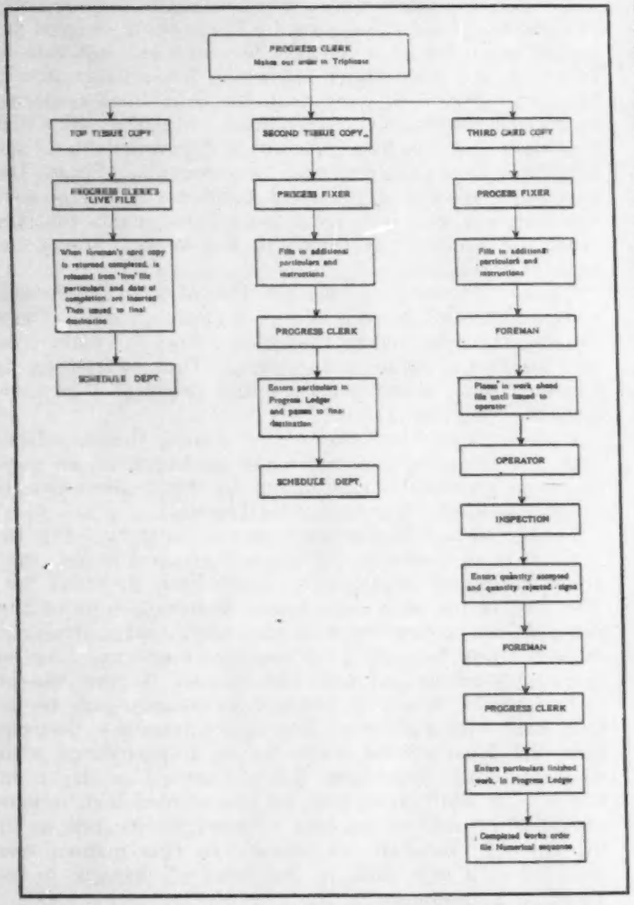

PROGRESS CLERK
TOP TISSUE COPY
SECOND TISSUE COPY
THIRD CARD COPY
PROGRESS CLERK'S "LIVE" FILE
PROCESS FIXER
PROCESS FIXER
When foreman's card copy is returned completed, is released from "live" file particulars and date of completion are inserted. Then issued to final destination
Fills in additional particulars and instructions
Fills in additional particulars and instructions
SCHEDULE DEPT
PROGRESS CLERK
FOREMAN
Enters particulars in Progress Ledger and passes to final destination
Places work ahead file until issued to operator
SCHEDULE DEPT.
OPERATOR
INSPECTION
Enters quantity accepted and quantity rejected - signs
FOREMAN
PROGRESS CLERK
Enters particulars finished work in Progress Ledger
Completed works order file Numerical sequence

FIG. 2—CHART TO INFORM EMPLOYEES OF DOCUMENT ROUTES

The ideal system provides for the loss of any member of the clerical staff and the substitution of another, with the *absolute minimum* of effort on the part of either the management or the new member. In other words, no subordinate should be indispensable.

Turning again to the key plan (Fig. 1), the main routine to be followed in respect to an order can now be noted. In this plan it is impossible, without destroying its lucidity, to show the incidental routine, so the main departments are shown separately in full detail. Nevertheless, it will be found that these detailed sub-plans all dovetail into one another accurately. All this departmental information can be further supplemented by the publication of a "Works Bible," which should preferably be arranged on the loose-leaf principle, as under the varying conditions of today amendments and improvements of the original scheme are sure to take place.

THE "ORIGINATING" DEPARTMENTS

In the authors' scheme it will be seen that only a certain number of departments are allowed to correspond directly with a customer, and, furthermore, such correspondence is limited in its scope, according to the department concerned.

Incidentally, a précis is typed of all the important letters received, and each of the responsible departmental heads receives a copy of this précis, making him familiar with current changes and alterations.

During the present time, when all engineering firms are being worked to the utmost limit of their capacity, and more tenders are received than can be considered, the question of the directors' manufacturing sanction is practically unnecessary and matters are left more in the hands of the Chief Engineer. Under these circumstances the following is the procedure now generally in force.

An inquiry is first received by the Chief Engineer, who, if he is of opinion that it is work suitable for the plant at his disposal, or about to become free, releases a Works Estimate Form in duplicate, which he passes along to the Schedule and Estimating Department—via the Drawing Office, if there are tracings and prints or material lists required.

The Schedule Department, which should be controlled by a man with a combined technical and commercial training, then makes out a technical estimate, obtaining material costs from the Stores Records Office or the Purchaser, and labor costs from the Production Engineer or Rate-fixer.

The completed Works Estimate Form in duplicate is then returned to the Chief Engineer, who, after checking it, retains one copy and passes the remaining copy to the Secretary or Managing Director, who adds the necessary oncost (overhead) charges, fixes the desired profit, and passes the form to the Sales Department as an authority to issue an official quotation to the customer.

Further questions of terms and deliveries having been discussed by the Sales Department with the customer, after consultation with the Chief Engineer and Secretary—and providing everything is then satisfactory—the customer's official order is received by the Chief Engineer. The latter is then able to earmark or allocate his plant accordingly, and having done this he passes the customer's order to the Sales Office, which makes out a Sales Order in quadruplicate for distribution as follows:

(1) Forms confirmation of order to the customer.
(2) Is issued to the Schedule Department.
(3) Is issued to the Invoicing Department.
(4) Is issued to the Finished Stores.

When drawings in connection with the order are received by the Chief Engineer, they are passed to the Drawing Office, which makes out the material lists. These lists, with three sets of blueprints, are then issued to the Schedule Department, and that department has the necessary particulars to make out the Contract Schedule Sheet shown in Fig. 12.

Having recorded the particulars, and after consultation with the Chief Engineer, the Schedule Department makes out the Production Order in triplicate. The Production Orders are not replicas of the Sales Orders, but are split up into sections according to the manufacturing and costing requirements. This Order is the sole authority to the shop to commence work, and for costing purposes may bear a special cipher letter in addition to the number. The three copies are distributed as follows:

(1) Is issued with blueprints and material lists to the Progress Clerk, via the Production Engineer.
(2) Is issued to the Finished Stores as an intimation of completed work to be expected.
(3) Goes to the Cost Office for obvious reasons.

On the key plan (Fig. 1) the Invoicing Department is

SIDE GUIDE & GRIPPER

shown separately from the Sales, but these departments may be combined if necessary. It will thus be seen that all the necessary transactions between the customer and the firm are undertaken by five departments. The Accountants' and Secretary's Departments, of course, issue the usual statements and receive payments, and undertake all correspondence in connection therewith.

The Sales Office (Fig. 10) deals with the customer only in matters affecting the commercial aspect, such as alterations affecting price, delays in delivery, transit difficulties and questions of price.

It is essential, however, that the Sales Office and the Chief Engineer's Office be always in close contact, and that nothing affecting the manufacture should be decided upon without consultation with the latter.

The Chief Engineer's Office deals directly with the customer on technical points, involving the contract as a whole, and in many cases it would be advisable that all correspondence passing to or from the Drawing Office, the Schedule Department and the customer, should pass through the hands of the Chief Engineer.

The Drawing Office confines its dealing with the customer solely to matters directly affecting drawings or blueprints, such as dimension queries, etc.

The Schedule Department deals with the thousand and one small technical queries which generally crop up in the execution of a large contract. In no case should the Production Engineer be allowed to arrange matters direct, as only confusion will result and the commercial aspect of the contract may be imperilled.

It must be mentioned here, and as will be shown later, the Schedule Department automatically receives from the shop a copy of each Works Order as issued, giving the number of the machine or machines on which the job will be worked, the date of commencement, and the estimated date of completion.

This Department is also notified automatically by the shop immediately each Works Order is actually completed, and with these particulars at its disposal, it is a comparatively simple matter to keep up to date the Contract Schedule Sheet and also the Machine Capacity Record.

Special attention is here drawn to the Machine Capacity Record Board, which is kept up to date daily in the Chief Engineer's Office (Fig. 3). This enables the machines in use to be seen at a glance, and, supplemented by the Machine Capacity Record Sheets (Fig. 4), is of the utmost help in providing the Chief Engineer with the necessary information to keep the productive machine capacity of the Works up to its utmost limit.

The method of working the Board is perfectly simple once the necessary information is arranged to come through automatically. As will be seen from the illustration, small hooks are provided beneath each machine reproduction—in this case these were photostat silhouette prints of each machine—and also a set of different colored washable ivorine tag labels. Each tag bears the Production Order Number and the date of commencement of the job, together with the estimated date of completion. The machines actually in use should bear a blue tag, those having work ahead allocated to them, a yellow tag, and those broken down, a red tag. Machines without any present or future work would have no tags at all on their respective hooks.

One other duty of the Schedule Department is the technical supervision of the material tests either at the suppliers' works or upon delivery as arranged by the purchaser.

This completes the full scope of the Originating Departments, and we can now treat with the preparation or planning necessary in the works offices before the job is actually undertaken.

THE "PREPARATION" AND "PLANNING" DEPARTMENTS

The preparation for actual production in the works, see Fig. 11, is done by various departments, all under the direct supervision of the Production Engineer, the series of sub-departments being sometimes known as a Planning Department. Tracing the main routine of our plan, it will be seen that the sole link between the Executive Offices and the Works is the Schedule Department, which issues the authority to the latter to produce. This authority can be traced downwards in ever-widening branches similar to the genealogical trees familiar to history. The origination is, of course, the actual Sales Order, made

MACHINE CAPACITY RECORD. FOR MONTH ENDING SECTION

Machine Designation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

FIG. 4—FORM USED BY CHIEF ENGINEER TO RECORD PRODUCTIVE CAPACITY OF MACHINES

SIDE GUIDE & GRIPPER

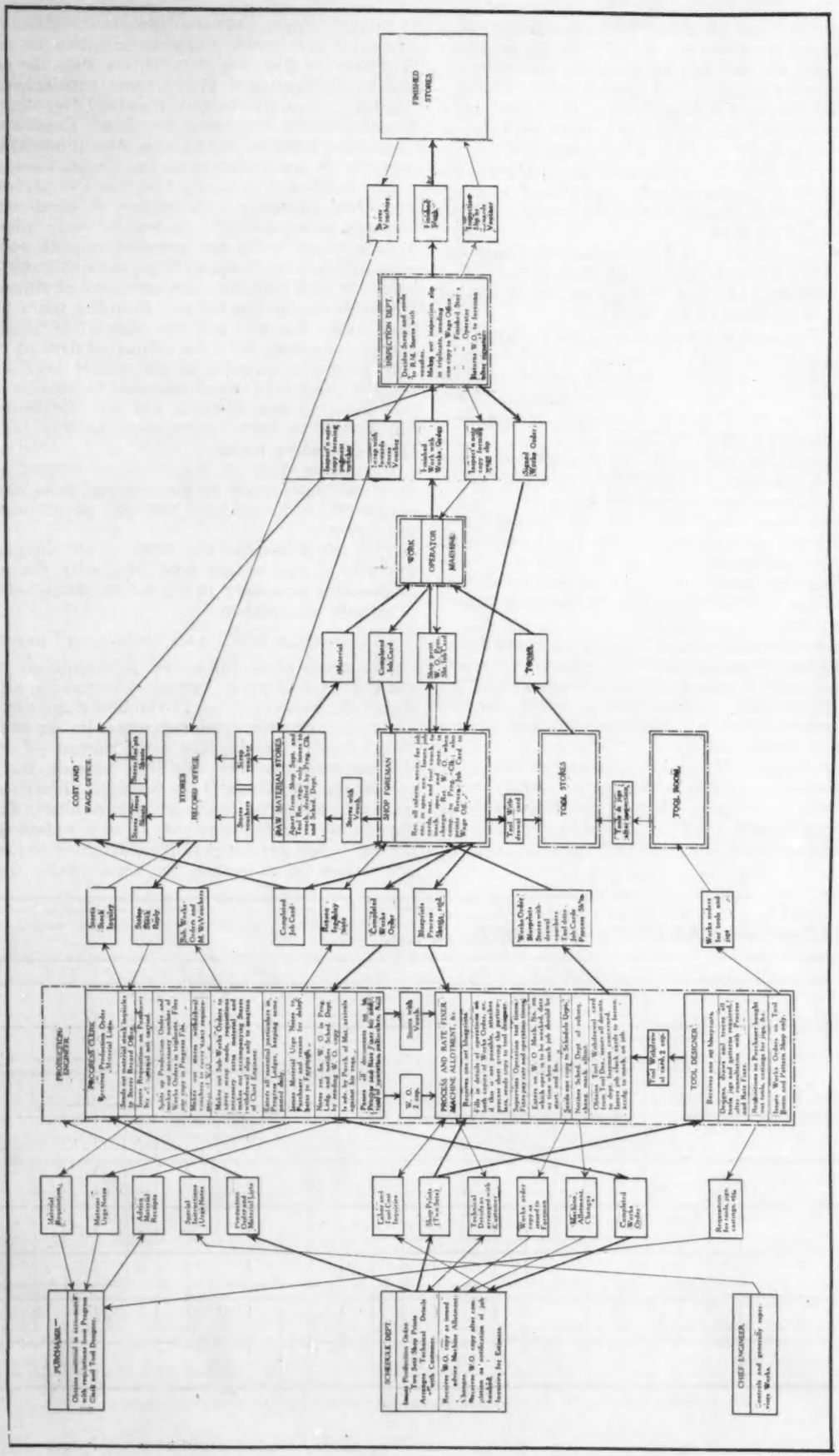


FIG. 11—CONTRACT ROUTINE AS AFFECTING THE PRODUCTION ENGINEER. MAIN ROUTINE INDICATED BY HEAVY LINE, INCIDENTAL ROUTINE BY LIGHT LINE. LINE OF DOTS AND DASHES AROUND DEPARTMENTS OR OFFICIALS INDICATES PRODUCTION ENGINEER'S CONTROL.

out to cover the complete job. This Sales Order is then split up by the Schedule Department after consultation with the Chief Engineer, from a manufacturing point of view, and the Secretary, from a cost point of view, into a number of Production Orders. These are the only authority for the Shop to begin manufacturing, and nothing must be started until they are issued, or costing errors are immediately perpetrated. The Production Orders are in their turn split up into Works Orders, covering each component part and in quantities such as will not necessitate the Works Order being "open" for more than a limited period. The Works Orders in their turn are split up into Job Cards, of which one is issued for every operator or machine engaged on that particular work.

Put briefly, the scope of each Order is as follows:

The Sales Order is merely a standardized copy of the customer's order to the Works as a *whole* to produce a definite amount of work.

The Production Order is the order to the Shop.

The Works Order is the order to the foreman.

The Job Card is the order to the man.

In the same manner that the main Sales Order was divided, then sub-divided, and again sub-divided, so, when the work is completed, must all these sub-orders be returned step by step, in the same manner in which they were given out. In the scheme under discussion, it is now proposed to show how this is done.

We begin at the Schedule Department, which issues to the Progress Clerk (via the Production Engineer) the Production Order, the Material Lists, and one set of Shop Prints, while, simultaneously, another set of Shop Prints goes to the Tool Designer. The Progress Clerk splits up each Production Order and makes out the necessary number of Works Orders, one for each component. The Works Orders are in triplicate: two tissue copies and one card, Fig. 5.

The Progress Clerk then checks over the Material List, sends an inquiry to the Stores Record Office and requisitions on the Order Department any goods not stocked. He makes out the Stores Withdrawal Vouchers, which cover only the quantity of material required for the particular Works Order. He enters all particulars in the Progress Ledger and files one copy of the Works Order in the "live" progress file, and passes on the remaining two copies, the Shop Prints and the Stores Vouchers to the Process Clerk. The latter having made out the Process Sheet which is issued to the central file in the shop foreman's office, fills in the reference particulars on both copies of the orders to which it has reference. The Process Clerk and Rate-fixer supervises test operations, and times and fixes piecework rates, enters on both copies of the Works Order the Machine Number on which work is to be carried out, and notes the time or date when that work should be completed by the machine on which it is to be operated.

As soon as it is decided to issue the job to a departmental foreman, the date is noted on both copies of the Works Order, and one copy is sent to the Schedule Department, via the Progress Clerk, as a notification of the work having been put in hand. The Works Order, the Process Sheet, one set of Shop Prints, and the Store Vouchers, together with the Tool Withdrawal Card received from the Tool Designer, are then issued as a complete set to the department foreman concerned. The foreman then allots his men to the various machines specified on the order, first drawing from the Clock Office the necessary number of Job Cards, one for each man. He issues to each man the Tool Withdrawal Card or Cards covering the particular tools required for the job,

Works Order. No.....

Date.....Production Order No.....

Particulars.....

.....Print No.....

Quantity.....Required by.....

Section.....Material.....

Job issued.....Job finished.....

Remarks.....

M/c No.	Start.	To be Finished.	Process Sheet No.	Operator's Check No.	Total Quantity.	Quantity Good.	Quantity Bad.	Inspection.

Works Order must not cover work in more than one Section

The routine instructions on the respective forms are—

1. PROGRESS CLERK.—Enter initial particulars in Progress Ledger and place this copy in "live" file. Follow up immediately overdue. On receipt second copy back from Rate Fixer, complete particulars in Ledger and pass to Schedule Dept.
2. PROGRESS AND RATE FIXER.—Complete particulars on this and Card Copy. Issue Process Sheet, if necessary, to Foreman. Immediately Card Copy issued to Foreman insert date on this copy and send to Schedule Dept. via Progress Clerk.
3. FOREMAN.—On receipt of this Card draw and issue Job Cards to Operators assigned to machines specified. Report any difficulty in completing to time to Progress Clerk. On completion IMMEDIATELY sign and return this Card to Progress Clerk.

FIG. 5.—WORKS ORDER IN TRIPLICATE. NOTE DIFFERENT ROUTINE INSTRUCTIONS ON EACH COPY

as arranged by the Tool Designer, and as specified on the Process Sheet. He also issues the Stores Withdrawal Vouchers, enabling the necessary material, and no more, to be drawn for the job.

By this time it will be seen that the machine and the operator are in possession of the raw material and the tools. It is only necessary then to issue the Shop Prints and Job Cards for the work to be proceeded with. Process Sheets are placed in a permanent file in the Shop Foreman's Office for reference to by charge hands, etc., Fig. 6.

WORK OF INSPECTION DEPARTMENT

Upon completion, the man passes the finished work to the next operation—if no intermediate viewing is necessary—the foreman always noting on the Works Order that the stated amount of work has been completed. In the case of piece work it will, of course, be viewed by the Inspection Department, and in this case the finished work goes through with the Works Order, the Inspector noting on the latter the number passed and the number scrapped.

With regard to the finished goods, upon these being presented by the Operator, the Inspection Department makes out the inspection slip in triplicate, one copy goes to the Wage and Cost Office, forming the Payment

SLIDE RULE & CUTLER

Voucher, the second copy goes to the Operator, forming Wage Payment Slip, and the third copy goes to the Finished Stores with the goods, forming the Stores Inward Voucher. This voucher is passed on to the Stores Record Office by the Finished Stores and is collected and amalgamated with the other information passed to the Cost Office.

It will therefore be seen that no single document is issued without its having a final destination, but a great deal depends upon an energetic Progress Clerk, who would arrange his own clerical system in such a manner that inquiries would be instituted immediately any documents became overdue.

The Foreman then collects from the Operator the Works Order signed by the Inspection Department, the Job Card, the Shop Prints, and the Process Sheet. The Job Cards are then entered on time sheets and forwarded to the Cost Office. The completed Works Order and the Shop Prints are then passed back to the Progress Clerk in the Production Engineer's Office. The completed Works Order then releases from the Progress Clerk's "live" file the copy Works Order he has there. This is then filled in with the date of completion and number of pieces completed and forwarded to the Schedule Department as an intimation that that particular section of the Production Order is finished.

In order to keep track of the progress of work called for on each Production Order, it is necessary to have some form of bookkeeping which will show at a glance the exact position of every portion of the contract in order that certain sections can be speeded up. For this purpose the authors designed what is known as a "Progress Ledger," and in this there is opened what might be termed a Ledger Account for each Production Order. The Shop is debited with every Works Order issued, and credited with every one returned completed.

The Progress Ledger, as will be seen from the specimen page, Fig. 7, shows the number of parts called for by the Production Order. It also shows the number of Works Orders issued covering that quantity, and on the right of that is shown the actual quantity completed to those Works Orders. Any deficiency to be made up owing to scrap must be done only on a Sub-Works Order, which should be a distinctly colored card, and a separate set of Stores Withdrawal Vouchers must be issued with it. This Sub-Works Order would only be issued by direction of the Chief Engineer. By this means the progress at any time of any particular order, or part of an order, can be easily ascertained.

CLEARANCE TO DESTINATION

The organization system provides, as far as humanly possible, the maximum of safety with the minimum possibility of goods being despatched without invoicing or checking, or to the wrong destination.

In practice the scheme works as follows:

Assuming the finished goods have arrived in the Finished Stores, and that they are in accordance with both the Sales Order and Production Orders—copies of both being in the Stores' possession under the authors' arrangement—the Storekeeper makes out a Notification

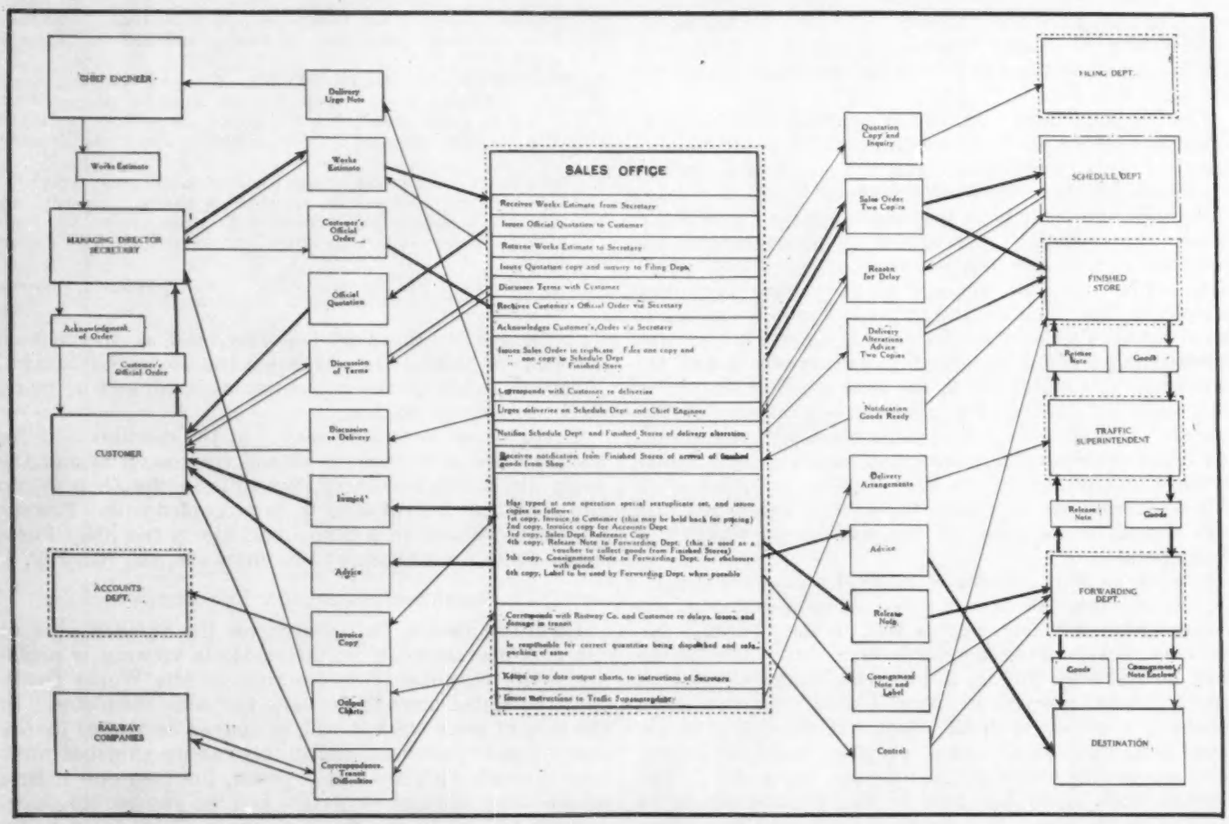

CHIEF ENGINEER
Works Estimate
MANAGING DIRECTOR SECRETARY
Acknowledgment of Order
Customer's Official Order
CUSTOMER
ACCOUNTS DEPT.
RAILWAY COMPANIES
Delivery Urge Note
Works Estimate
Customer's Official Order
Official Quotation
Discussion of Terms
Discussion re Delivery
Invoice
Advice
Invoice Copy
Output Charts
Correspondence, Transit Difficulties
SALES OFFICE
Receives Works Estimate from Secretary
Issues Official Quotation to Customer
Returns Works Estimate to Secretary
Issues Quotation copy and inquiry to Filing Dept.
Discusses Terms with Customer
Receives Customer's Official Order via Secretary
Acknowledges Customer's Order via Secretary
Issues Sales Order in triplicate. Files one copy and sends one copy to Schedule Dept. Finished Store
Corresponds with Customer re deliveries
Urges deliveries on Schedule Dept. and Chief Engineer
Notifies Schedule Dept. and Finished Stores of delivery alterations
Receives notification from Finished Stores of arrival of finished goods from Shop
May typed at one operation special sextuplicate set, and issues copies as follows:
1st copy, Invoice to Customer (this may be held back for pricing)
2nd copy, Invoice copy for Accounts Dept.
3rd copy, Sales Dept. Reference Copy
4th copy, Release Note to Forwarding Dept. (this is used as a voucher to collect goods from Finished Stores)
5th copy, Consignment Note to Forwarding Dept. for enclosure with goods
6th copy, Label to be used by Forwarding Dept. when possible
Corresponds with Railway Co. and Customer re delays, losses, and damage in transit
Is responsible for correct quantities being despatched and safe packing of same
Keeps up to date output charts, to instructions of Secretary
Issues instructions to Traffic Superintendent
Quotation Copy and Inquiry
Sales Order Two Copies
Reason for Delay
Delivery Alterations Advice Two Copies
Notification Goods Ready
Delivery Arrangements
Advice
Release Note
Consignment Note and Label
Control
FILING DEPT.
SCHEDULE DEPT.
FINISHED STORE
Release Note
Goods
TRAFFIC SUPERINTENDENT
Release Note
Goods
FORWARDING DEPT.
Goods
Consignment Note Enclosed
DESTINATION

FIG. 10.—CONTRACT ROUTINE AS AFFECTING SALES DEPARTMENT.
MAIN ROUTINE INDICATED BY HEAVY LINE. INCIDENTAL ROUTINE BY LIGHT LINE, SECRETARIAL CONTROL BY LINE OF DASHES AND CHIEF ENGINEER'S CONTROL BY LINE OF DOTS AND DASHES

Slip. This, if necessary, can be in triplicate, one copy going to Invoice Clerk, another copy to Sales Department (if distinct from the Invoice Clerk), and the third to the Schedule Department for recording on the Contract Schedule.

On receipt of the Notification or Clearance Slip, the Invoice Clerk types out at one operation a special sextuplicate set of forms, distributed as follows:

(1) Forms the invoice to the customer, and this may be held back for pricing later, if desired.
(2) Is issued to the Accountants' Department.
(3) Forms the Sales Department reference copy.
(4) Forms a "Release Note," is issued to the Forwarding Department, and is used as a voucher by the latter to collect the goods from the Finished Stores.
(5) Forms the "Consignment Note," and is issued to the Forwarding Department for inclosure with the goods. This copy may be sent separately as an advice to the customer, if so required.

Production Order No.....
Piece Name.....
Component of.....

Process Sheet No. 1.

(Numbered upward in triplicate)

Drawing Number.....
No. Off per Set.....
Material.....
Date.....

Operation No.	OPERATIONS.	TOOLS.	Jig No.	Gage No.	Machine to use.	Remarks.

The routine instructions on the respective Forms are:

1. PROCESS FIXER.—Make this form out in triplicate, but add additional spare copies if more than one mounted copy is issued to shop. However many extra copies are issued, all must bear same number. File one copy. Issue remainder to Foreman. Al mounted except Pink Copy for Foreman's File.
2. FOREMAN.—File this Copy in numerical sequence in permanent special binder provided. Issue mounted Blue Copy or copies to Operator with working drawings. Return all copies on completion of Contract.
3. OPERATOR'S COPY.—This should be mounted and issued with working drawings.
4. EXTRA OPERATOR'S COPY.—This should bear same number as original Process Sheet in Office File and be issued with working drawings.

FIG. 6.—PROCESS SHEET WHICH IS ISSUED IN TRIPLICATE TO FOREMEN, ALSO CONTAINS OPERATION INSTRUCTIONS

Progress Ledger.

Production Order No.....Date.....
Particulars.....Quantity.....
Delivery Required.....

Works Order No.	Date	Quantity for.	Voucher Nos.	Date.	Material for.	Date W. O. issued to Shop.	Date returned completed	Quantity good.	Quantity bad.	Remarks.

N.B.—No Works Order should cover more than Six days' work in the Shop. If not returned within a week from date of issue, follow up. If original W. O. lost, do NOT issue another one with a fresh number. Make out the special replacement order from copy in Progress File and quote original number. Sub Works Orders must be the only shop orders to cover scrap and must only be issued by special sanction of Chief Engineer. Report to Chief Engineer all Production Orders requiring issue of Sub-W. O.'s to cover scrap.

FIG. 7.—SPECIMEN PAGE FROM LEDGER USED TO SHOW NUMBER OF PARTS ON ORDERS

.....STORES please receive as under. A.....

Ex PRODUCTION ORDER No.....Date.....

Dept.	Quantity	Description	Part No.	Cwt.	Qrs.	lb.	Rate	£	s.	d.	Folio

Foreman's Signature.....

FIG. 8.—SPECIMEN "INWARDS" VOUCHER (PINK) ACCOMPANYING ALL MATERIAL PASSED INTO STORES

.....STORES please supply as under. F.....

For PRODUCTION ORDER No..... Date.....

Bin No.	Quantity	Description	Part No.	Cwt.	Qrs.	lb.	Rate	£	s.	d.	Folio

Foreman's Signature.....

FIG. 9.—SPECIMEN "OUTWARDS" VOUCHER (WHITE) FOR DRAWING MATERIAL FROM STORES

(6) Forms the label for affixing to the package.

It is, of course, understood that the forms used are of different widths across in order that the prices appear only on those forms on which they are necessary. It is thus seen that it is impossible for the goods to leave the Finished Stores without *an invoice being made out to cover such issue.*

INCIDENTAL ROUTINE

Dealing with the incidental routine, it should be noticed how the Schedule Department will apply to the Production Engineer for labor costs, upon which the former will base the estimates. Technical details arranged with the customer subsequent to the order being placed would always be dealt with through the Schedule Department, and never direct with the Shop, but, if important, via the Chief Engineer. The Schedule Department will issue a note, if necessary, asking the reason for delay, and the Progress Clerk in his turn will ascertain from the departmental foreman why the job is being held up.

In the majority of cases tools will be made to a Production Order held by the Tool Designer, who will issue the necessary Works Orders on the tool room or pattern shop. The Tool Designer will also requisition on the Order Department for tools bought out and jig castings, etc.

The Cost and Wage Offices automatically collect the necessary information to give them the final costs of the job in the following manner: The Stores Vouchers handed in either with finished work, scrap, or for goods, see Figs. 8 and 9, are passed along to the Stores Records Office, which in its turn collects all the information on sheets of the Stores Issues and Stores Receipts, passing it on to the Cost Office. The complete Job Card and Time Sheet having already been passed to the Cost and Wage Offices, as previously mentioned, this is all the information required from the Shop.

The Wage Office, of course, checks the total times clocked by any one operator on his various jobs, and these are summarized in a Weekly Time Sheet, against the total time as shown by his Weekly Time Card.

AUTHORS' CONCLUSION

The authors hope that sufficient matter has been presented to form a basis upon which an organization which will be economical to work can be successfully founded.

The procedure outlined is that necessary to insure that Shop activities have a definite ultimate aim, with the responsibilities of the operators and executives clearly defined, and to eliminate overlapping and duplication of effort.

The success or failure of an organization of this description depends almost entirely upon the way in which it is adhered to by the managing heads. That is to say, that although in some instances it may be irksome for the latter to follow strictly the current routine, if they depart from the system as laid down and take "short cuts," they set an example which is bound to be followed by subordinates, and the result is chaos.

CONTRACT SCHEDULE FOR MONTH ENDING.....

Customer..... Customer's Order No.....

Sales Order No..... Date..... Deliveries required by.....

Prod. " " ..... Delivery rate.....

Description of Part	Customers Part No.	D. O. Record No.	Number per Set	Number of Sets	Total Units Required	Made on Machine No.	Delivery Quantity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
							Scheduled																																
							Passed Insp'r																																
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FIG. 12—CONTRACT SCHEDULE FORM DESCRIBING PARTS ORDERS RECEIVED DURING ONE MONTH

Standardization of Assembled Military Truck Parts

AT the conference on military-truck specifications held July 20 and 21 at the Hotel Deshler, Columbus, Ohio, under the auspices of the Society, announcement was made by representatives of the War Department that standardized assembled military trucks are to be built with all parts absolutely interchangeable. The engineers who voluntarily have given their time to the standardization of units for military trucks during the last six weeks, will be asked to continue their work, although their status will be slightly changed, because they will be paid directly by the government and will be expected to spend in Washington whatever time is necessary to finish the work at the quickest possible moment. The makers of vehicles most nearly filling the requirements of the War Department will supply the equipment needed at once. When standardized trucks are proved a success and can be obtained in quantities, it is expected that large purchases will be made by the War Department.

The government desires trucks of the maximum going ability for use in carrying supplies to the men at the front. After the design is finished by the engineers' committee to be employed, the design will be checked by the best engineers of the country. Model trucks will then be built and subjected to the most severe tests. When the requirements are known the manufacturers best able to produce the assembled trucks will be assigned the work.

The present program is to carry standardization to the absolute limit and have every unit and every one of its parts absolutely interchangeable. If it is found that this program interferes with obtaining a reasonable quantity of any units when they are needed, then it may be necessary to use the parts already in production in the assembly until the parts can be thoroughly standardized.

The War Department has made arrangements to continue this work of standardization. Many members of the groups who have carried the work out thus far have been asked to find out just how much time they could give to the work at Washington, and then they will be notified in the future as to the details of the service requested of them.

PRELIMINARY WORK

It will thus be seen that to date the military truck specifications have passed through two separate stages:

(1) The preparation and criticism of the specifications issued for the 1916-1917 fiscal year of the Government.

(2) The interpretation of these specifications necessary to secure an assembled truck made up of interchangeable units.

The work under (1) was directed mainly by the Truck Standards Division of the Society, which made a draft of so-called ideal truck specifications. The Motor Transport Board of the War Department also revised the specifications. The final specifications issued in May were the result of the cooperation between the two parties. During the progress of the work the Electrical Equipment, Springs and Tire and Rim Divisions of the Standards Committee were called in to give advice on various points. The work of these Divisions in cooperating with the Government was approved at the May meeting of the Standards Committee. The specifications do not, of course, constitute a standard of the Society, except insofar as standards established by the S. A. E. are included in the specifications.

The work under (2) has all been done in the last six weeks.

UNIT STANDARDIZATION

Now that the Society's part of it has been finished successfully it seems desirable to review what it was hoped to accomplish. The work has been carried on directly by the engineers connected with parts and truck manufacturers. It was conducted under the auspices, to a certain extent, of the Standards Committee of the Society.

The Society's part in the work, as Chairman Utz of the Standards Committee has aptly expressed it, has been that of a chairman giving guidance and promoting cooperation. The machinery of the Committee has been used in handling such details as sending out calls for meetings, keeping a record of the action taken, and in general using the experience gained in carrying on S. A. E. standardization work in the belief that the results to be obtained will be of the greatest service to the Nation.

It is to be remembered that the main object of the proposed standardization of units was to enable the makers of such parts to design them so that the assemblers could produce standard military trucks. When these specifications were first issued by the War Department it appeared that many makers of units were not able to meet the specifications. Also makers of assembled trucks, which will be needed in large numbers, were not able to secure units to meet the specifications. Representatives of several engine makers met in Washington early in June to go over parts of the specifications with Captain Britton of the Quartermaster Department. The result of this conference was so gratifying that the transmission makers were called together; they suggested the possibility of building interchangeable transmissions. This led to the consideration of the bearings, and the bearings men were invited to take part in the work. Later the axle men were assembled and it was suggested that the work of these various groups should be laid out on a drawing to see what sort of an assembled truck would result.

TRUCK CONFERENCES

The first conference was held in Washington early in June and the work was continued at meetings held there on the 14th, 15th, 16th, 25th and 27th of that month.

The last Washington meeting showed that a great deal of work could be done if a meeting was held in the Middle West, where a larger attendance could be had. A conference was therefore held July 9 at Columbus and was continued the next day. The meeting at Columbus, on the 20th and 21st, was held to consider the reports on chassis details for the Class A assembled truck and to proceed with the Class B chassis layout. The layout for

both Class A and Class B trucks was practically completed before adjournment.

While the foregoing indicates when general meetings have been held, a number of meetings of groups appointed to consider the principal parts, such as engines, axles, transmission and ball bearings, have also taken place. Thus in the intervals between the meetings of the main body an immense amount of progress has been made.

At the meeting held in Washington, June 27, the engineers in attendance were divided up into the following groups: Chassis, transmission, front and rear axles, springs, universal joints, and ball and roller bearings. These groups separated to consider their own particular problems. The chassis group started to make an assembled drawing of the Class A truck. Questions immediately came up as to the frame width, the gage of the front wheels, the transmission location, length of propeller-shaft, and it was necessary to take these matters up with the groups considering them. This illustrates how the work of the several groups interlocks, this naturally resulting in many inter-group conferences. In fact, the whole work has progressed in a cycle somewhat as follows: The chassis group would make a layout of the assembled truck, and difficulties might be met in using some of the dimensions recommended by the various groups. These would then make suggestions to overcome the objections raised by the chassis group, which would revise its layout accordingly.

PROPER TRANSMISSION LOCATION

The method of procedure can best be appreciated by the following outline of the work done by the various groups. The transmission group has been engaged in the design of a unit that can be used in all the assembled trucks. It was found, however, that several makers believe that their product can be completely standardized. This group has submitted detailed recommendations for Class A and Class B truck transmissions, including shifter-rod location, support dimensions, distance from center of main shaft to bottom of transmission and tapers for gear-shaft ends.

Considerable time was devoted to a discussion of the transmission location. The marked difference in the driving angles (of propeller-shaft) for worm-drive and internal-gear drive type of axles, taking into consideration spring deflections and rebound conditions, apparently makes it impossible to use both types of axles with the same position of transmission. This matter will receive further attention by the Government committee to be appointed to standardize military trucks.

The axle group has made considerable progress in obtaining uniformity in the center-to-center spring distance for Class A and Class B types. This involves necessarily the correlation of a number of details connected with the construction and assembly of springs. It was decided that in order to standardize the location of the brake lever that both brakes must be placed on the wheels, thus eliminating the propeller-shaft brake. The axle makers have agreed to secure a common fore-and-aft location of brake levers by the application of an idler lever to which the pull rods will be attached. It was decided to recommend that propeller shafts should be changed, together with axle units, as it was found impossible to use the same length of shaft for worm and internal gear axles.

The members of the springs group have agreed on a uniform width and length for the springs of both Class A and Class B trucks. These springs have been standardized from end to end and from top to bottom. The plates can therefore be made interchangeable.

The ball and roller bearings group has held a number of conferences with the transmission and engine group in regard to sizes of bearings. It has been found possible to recommend transmission bearings of the annular ball, straight roller and tapered roller type so that they can be used with the parts laid out by the transmission group.

ENGINE SPECIFICATIONS

The engine group has recommended alternative specifications, these being prepared with the cooperation of Captain Britton. The Class A truck-speed is to be 14 m.p.h., engine speed, 1100 r.p.m.; axle ratio, 8.5 to 1 (calculated); transmission ratio, first and fourth speeds, 5 to 1; engine torque, 2100 lb. in. (2400 max.). The tractive factor as calculated would be 0.0782 on high gear and 0.332 on low gear. For Class B trucks the speed is to be 12 m.p.h.; the engine speed, 1050 r.p.m.; axle ratio, 9.36 to 1, calculated; transmission ratio, first and fourth speeds, 5.59 to 1; engine torque 2700 lb. in. (2900 max.). The tractive factor as calculated will be 0.0736 on high gear and 0.338 on low gear.

The engine group has practically come to an agreement on engine supports and clearances. The sizes and center distances have been specified. Considerable attention has been given to the cooling system and the sizes of fan ball bearings have been determined. Definite action has been taken in regard to the location and sizes of such fittings and attachments as the carbureter, oil indicator, valves and magneto, drive-shafts and couplings.

The electrical equipment group has made recommendations relating to the location and position of the generator and starting motor.

The subject of ignition was also considered and a system making use of two separate sets of spark-plugs recommended. An alternative proposal was also submitted, to be used in case only one set of plugs is specified.

PROPELLER-SHAFT ANGLE

The universal joints group recommends that the maximum angle of propeller-shafts should not be more than 10 deg. and that the running angle be 5 deg., although a slightly greater angle would not be objectionable.

The steering-gear group believes that a wood steering-wheel rim with some form of waterproof coating, this being more endurable than varnish finish, would prove more satisfactory than a rubber or composition rim. Definitive proposals were made by this group relating to the steering-gear ratios, diameter of ball and end of steering-arms and the method of attaching steering gears to the frame. Outside types of control are recommended, and the distance is specified between center line of steering column and center lines of the controls.

WILLIAM G. BEE

WILLIAM G. BEE, vice-president and general sales manager of the Edison Storage Battery Company, died July 11, at his home in Orange, N. J., after an illness of over two years. Mr. Bee was born March 18, 1872, at Hartford, Conn., and spent fifteen years in the United States Navy. He left the Navy immediately after the conclusion of the Spanish-American War and entered the employ of the Columbia Electric Vehicle Company; later he was with the Electric Vehicle Company of Hartford. Since 1902 he had been with the Edison Storage Battery Company. Mr. Bee was elected a member of the Society Aug. 31, 1910.

Aeronautic Division Meeting

July 16 - - - - - Washington

TACHOMETER drive, magneto dimensions, definition of complete aeronautic engines, specifications for glue used in airplane construction and use of airplane bolts and nuts were the main subjects considered at the Division meeting held July 16 at the Munsey Building, Washington.

The subject of protective coatings for metals was discussed, and F. G. Diffin is to secure as soon as possible samples of such work from various manufacturers. These are to be sent to the S. A. E. New York office, where arrangements for testing them will be made.

Tachometer Drive.—A report was presented by Dr. H. C. Dickinson of the Bureau of Standards stating that the question could not be settled until the type of tachometer was determined, since the characteristics of the different instruments make entirely different demands upon the drive. A large number of English and French instruments have been investigated, but there seems to be no unanimity of opinion as to the type of instrument most desirable. Apparently there is a demand for an instrument of the escapement type. Steps are therefore being taken to ascertain whether such an instrument can be produced in this country. It may then be possible to determine whether the escapement type is necessary or a less expensive instrument can be used.

The multiple wire-wound shaft with the core wire is recommended for tachometer drive. The shaft casing should be as small as possible and not over ½-in. outside diameter. A shaft with a core and with suitable provision for changes in length will probably be preferable to the shaft used by the French, which is made without a core and with the two ends rigidly held in position, so that the shaft must stretch to accommodate changes in length of the flexible casings.

In discussing the report Doctor Dickinson recommended camshaft speed for the tachometer drive. He also stated that the centrifugal instruments required a speed of 200 r.p.m. before registering. It was said that the escapement type of tachometer could be operated at either camshaft or engine speed, without changing the mechanism; it was simply necessary to change the dial reading. It is important that tachometers register accurately at high speed, because the pilots must know the condition of their engines before attempting certain classes of work in the air. It is also necessary to have the tachometers register accurately at low speed in order to make proper landings.

Definition of Complete Aeronautic Engines.—Major Henry Souther of the Aviation Section has requested the Division to consider a definition of complete aeronautic engines. It is desirable to have some clear distinction between the plane and engine. The plane will include such parts as have been omitted from the engine. The following definition is therefore proposed by Major Souther for this purpose:

"A complete aeronautic engine is considered to include all component parts for proper functioning, with the exception of the following: Gasoline tanks, independent piping and hose, radiator and starter equipment, muffler and muffler pipes, oil cooler and independent sump. Tachometer-drive attachment is to be included, but not the tachometer or flexible shaft. Electric-ignition equipment is included, but not the connecting wires. The propeller flange, hub and bolts are to be included, but not the propeller. A complete set of tools is to be furnished with each engine."

A committee of Division members was appointed to prepare a standard sheet in which engine weight and the weight of accessories can be tabulated so that engines of different makes can be compared on a reasonable basis. The question of just what will be included in the electric, starting and lighting equipment will also be considered by this committee, which will report at the next meeting of the Division.

Magneto Dimensions.—The following dimensions for eight and twelve-cylinder magnetos for airplane engines are proposed for standardization:

Height of magneto space, 228 mm., or 9 in.

Length of magneto space, 254 mm., or 10 in.

Width of magneto space, 127 mm., or 5 in.

A taper of 11 deg. 30 min. is recommended. The large diameter of the taper is to be 15 mm., or 0.590 in.; small diameter of taper 12 mm., or 0.472 in.; length of the taper 15 mm., or 0.590 in. A Woodruff key No. 3 is to be used with this taper.

Spark-Plug Tolerances.—A table of tolerances for 18-mm. spark-plug threads is reported to have been adopted by the Engineering (British) Standards Committee. This table follows:

DIMENSIONS OF SPARK-PLUG BODY

Diameter	MAXIMUM		MINIMUM	
	Mm.	Inches	Mm.	Inches
Outside	17.975	0.70768 (0.708)	17.850	0.70275 (0.703)
Pitch	17.001	0.66933 (0.669)	16.876	0.66441 (0.664)
Root	15.864	0.62457 (0.625)	15.739	0.61964 (0.620)

DIMENSIONS OF TAPPED HOLE

Diameter	MAXIMUM		MINIMUM	
	Mm.	Inches	Mm.	Inches
Outside	18.325	0.72146 (0.721)	18.187	0.71603 (0.716)
Pitch	17.176	0.67622 (0.676)	17.051	0.67124 (0.671)
Root	16.201	0.63783 (0.638)	16.076	0.63291 (0.633)

It was voted to recommend these tolerances both for spark-plug body and the hole into which it fits, for adoption by the S. A. E. Details of ends of threads in both parts will receive further attention.

Floats and Float Fittings.—It was decided that it would not be advisable at the present time to standardize the general design of floats, but that the details of any design used in general practice should be standardized. Among such details being considered are the step shoe, drain-plug, hand-holes and towing cleats. These subjects will be considered further, after an investigation has been made of French and English practice.

Rubber-Hose Tests.—Major Souther submitted the results of tests on gasoline hose made at the Bureau of Standards. Some of the samples examined were too

large and too heavy for airplanes, others swelled and lost elasticity on account of the gasoline. A metal-lined hose was said to be objectionable because it could not be cut and the length suitable for every type of machine had to be kept in stock. This was considered undesirable unless the distances were standardized between the tank and engine and between the carbureter and tank connections. Such hose is also heavier than the rubber-lined hose of the same diameter.

Glue for Airplane Construction.—The specifications for glue used by the Aircraft Engineering Division of the Signal Corps were discussed. They provide for a glue test-specimen made up of three 1-in. boards, 5 ft. long and 5½ in. wide. This specimen is to be glued and shall set not longer than one week. It will then be cut lengthwise and ten shear blocks cut from each half. These blocks are given two tests, one immediately after sawing and the other after being soaked for fifteen hours in a 5 per cent solution of sodium chloride. The latter test must be made within three minutes after removal from the water without any preliminary drying. In the first test it is necessary the strength of the glue in shear shall not be less than that of the wood. After soaking in salt water the strength shall not be less than 60 per cent of the strength under atmospheric conditions. Some objection was made by members of the Division to these requirements. It was thought that they covered a type rather than a routine test.

Airplane Bolts and Nuts.—Chairman Manly submitted a report showing the practice now followed by the Curtiss company as regards use of thread. Screw-threads are needed with threads finer than the S. A. E. standards, principally for parts like nuts for brazing unions, filler caps and drain plugs. The report suggested standardizing the ends of bolts so as to have radius equal to the bolt diameter; it also gave dimensions of plain and lock washers suggested for standardization on airplanes.

Other subjects considered were wing attachments to bodies, tension wire cables, engine control, and engine testing. A committee was appointed to prepare specifications for both engineering and routine tests.

The next meeting of the Division will be held Tuesday, July 31, at Washington.

MILITARY-MOTORCYCLE STANDARDIZATION

A LARGE number of important subjects were considered at the motorcycle meeting held June 28, at Washington, under the auspices of the Society, Standards Manager M. W. Hanks acting as chairman. It was decided to recommend that a military motorcycle rim should have 28 by 3-in. clincher tires and the standard cc section with 40 spoke holes 17/64 in. diameter, suitable for receiving the standard ¼-in. nipple. All military motorcycle tires should be of the clincher type, 28 by 3 in. The rim and tire dimensions apply to front and rear wheels as well as to side-car and rear-car wheels.

The repair spokes for front and rear motorcycle wheels, as well as for side-car and rear-car wheels, are to be as follows: Length, 10⅞ in. from neck of head to tip; total length of swedge, 2 in.; diameter of swedge, 0.135 in.; length of thread, 1⅛ in.; number of threads to the inch, 40; diameter of spoke, 0.110 in.; and diameter of head swedge, 0.135 in.

It was decided that nipples of the following dimensions should be standardized for all spokes: Length under head, ⅞ in.; thickness of head, ⅛ in.; diameter of head, 11/32 in.; slot in head, 1/32 in.; length of wrench surface, 9/32 in.; width of wrench surface, 0.212 in.; and diameter of nipple, ¼ in.

The nipple is to be counter-bored to a depth of 5/16 in. in order to permit the spoke swedge of 0.135 in. to enter readily. The rest of the nipple is to be drilled and tapped for 0.135-in. swedge of 40 threads to the inch.

It was considered that the 18-mm. metric plugs should be standard on military motorcycles, but that the height of the plug above the threads should receive further consideration.

The lugs for attaching the head lamps for military motorcycles should have the following dimensions: Height, 1⅛ in.; width, 11¾ in.; and hole diameter, 25/64 in. The minimum clearance from the center of the hole to the lamp casing should be 11/32 in. radius.

The prongs of the head-lamp for military motorcycles should have the following dimensions: Height, 1½ in.; diameter, ⅜ in.; length of thread, 9/16 in.; number of threads, 24 to the inch, S. A. E. standard.

It was voted that military motorcycle driving chains should be of the roller type, ⅝-in. pitch, roller width ⅜ in., and diameter 0.40 in.

The throttle control on military motorcycles should be of a handle-bar-grip type, placed on the right-hand side, and operated to open the throttle by twisting the top of the grip toward the center of the motorcycle.

The spark control on military motorcyles should be of the handle-bar-grip type, placed on the left-hand side, and arranged to advance the spark by turning the top of the grip toward the center.

The clutch pedal on military motorcycles should be placed on the left-hand side and operated to release the clutch by pushing forward and down, clutching by reverse action.

The brake pedal on military motorcycles should be placed on the right-hand side, and operated to apply the brake by pushing down.

It was voted that the gear-shift lever-handle should be placed on the left-hand side and should be of the progressive type.

The kick starter on military motorcycles should be of the folding-pedal type, and operated by pushing down and back.

All oil and grease cups on military motorcycles should be 5/16 in. diameter, with 32 threads to the inch.

Fuel and lubrication pipes on military motorcycles should be 5/16-in. diameter. Fittings should be of the soldered type, with a ½-in. nut, 20 threads to the inch.

The total displacement of the cylinders on military motorcycle engines should be 61 cu. in.

It was voted that the maximum sprung load on military motorcycles should not exceed 500 lb., this including the weight of the operator. No load should be strapped or attached to any part of the frame of either the motorcycle or the side car.

Capt. Wm. M. Britton, Engineer of Motor Transportation of the Quartermaster's Department, U. S. A., attended the meeting and explained to those present the need for immediate standardization of military motorcycles. It is desired that as many parts and units be made interchangeable as possible. What is wanted is a construction that will have proved its ability to do the best and the most constant work.

The following were in attendance at the meeting: F. C. Butler, Jr., Wm. S. Harley, T. W. Henderson, C. O. Hedstrom, L. Ogden, B. F. Rogers, F. J. Weschler, Capt. Wm. M. Britton, General Manager C. F. Clarkson, H. L. Horning and M. W. Hanks.

STANDARDIZATION OF MACHINE-SCREW NUTS

A JOINT committee consisting of the Miscellaneous Division of the S. A. E. Standards Committee and of representatives of the American Society of Mechanical Engineers held a meeting June 23 at Washington to consider the possibility of standardizing dimensions for machine-screw nuts, in accordance with the suggestion made by Admiral D. W. Taylor, chief of the Bureau of Construction and Repair of the Navy Department.

Naval Constructor Furer explained that his department had asked for this standardization because of the necessity for uniform dimensions of nuts of all makes; the advisability of proportions progressing with tap sizes; and the advisability of conformity with parallel sizes of U. S. S. nuts.

The following table of dimensions for machine-screw nuts was proposed, this being based on data furnished by the Navy Department and by the members of the committee:

PROPOSED MACHINE-SCREW NUT DIMENSIONS

Size	Short Dia.	Thickness	
		Preferred	Alternate
2	3/16	...	...
3	7/32	5/64	5/64
4	1/4	...	...
5	9/32	3/32	3/32
6	5/16	7/64	...
8	11/32	1/8	1/8
10	3/8	9/64	...
12	7/32	5/32	5/32
14	1/2	5/16	5/16
18	9/16	...	...
20	19/32	1/4	1/4
24	11/16	5/16	5/16
30	25/32	3/8	3/8

These dimensions are intended to apply to steel and brass nuts of both hexagonal and square types. The square nuts are to have both the top and bottom flat. The hexagonal nuts are also to have the top and bottom flat, but the corners are to be chamfered beyond the inscribed circle at 30 deg. from the top surface.

It is planned to send these proposed dimensions together with a statement showing how they were prepared to all manufacturers of machine-screw nuts. Upon receipt of replies the committee will proceed further with the work.

The members of the Miscellaneous Division present at the meeting were: Chairman E. H. Ehrman, C. S. Crawford, J. E. Diamond, W. H. Knowles, H. H. Newsom, and E. E. Sweet. Mr. Ehrman also represented the A. S. M. E., as did E. Burdsall.

COUNCIL MEETINGS

THE June meeting of the Council was held on the 25th at the Bureau of Standards, Washington, those present being President George W. Dunham, First Vice-president J. G. Vincent, Second Vice-president Charles M. Manly, Councilors B. B. Bachman, David Beecroft, H. L. Horning, C. W. McKinley, F. E. Moskovics, Chairman of the Finance Committee H. M. Swetland, Treasurer Herbert Chase and General Manager Coker F. Clarkson.

A report was submitted for the Membership Committee showing that the membership of the Society was slightly in excess of 3000, this amounting to an increase of about 30 per cent during the current administrative year. It was decided to continue the membership work during the current fiscal year (until Oct. 1), the details to be handled by the New York office of the Society. A special committee, consisting of President Dunham, Councilors David Beecroft and F. E. Moskovics, was appointed to supervise the work.

It was voted that arrangements should be made to hold a dinner and meeting at Fremont, Neb., during the annual tractor demonstration, Aug. 6 to 10, and also that a meeting of the Tractor Division of the Standards Committee should be held at the same time. (Arrangements for the meeting are to be handled by the Meetings Committee, which has selected Aug. 8 and 9 as the dates.)

It was voted to make the following transfers in grade of membership: From Associate to Member, J. G. Anderson, Raymond Ware, D. Scott Campbell, J. E. Genn and Herbert T. Bagley; from Junior to Member, Charles O. Guernsey; and from Junior to Associate, H. W. Topley.

Applicants to the number of 389 were elected to membership in the Society, these being assigned to grades as follows: 103 Members, 224 Associate Members, 47 Junior Members, 4 Affiliate Members, 1 Affiliate Member Representative, and 10 Student Enrollments. The names of these members are listed on another page.

A committee of the National Gas Engine Association, consisting of Messrs. Kratsch, Keiser, and Secretary H. R. Brate of that organization, was present at the meeting, and reported that the Association had voted at its annual meeting, June 5 to 7, 1917, that its activities along engineering and standardization lines should be taken over by the Society of Automotive Engineers, and that members of the National Gas Engine Association should affiliate with the S. A. E. The Council decided that members of the N. G. E. A. in good standing who apply for membership in the S. A. E. on or before Sept. 15, 1917, should be received without payment of initiation fees. The following motion was then passed:

"The Council expresses its appreciation of the action of the National Gas Engine Association in voting to affiliate with the Society of Automotive Engineers. A hearty welcome and assurance of cooperation are extended to the members of the National Gas Engine Association."

It was voted to establish a new division of the Standards Committee, to be known as the Stationary and Farm Engine Division. The membership of this Division will be announced later.

The following men were appointed members of the Standards Committee, and were assigned to Divisions as indicated:

Dr. Edgar Buckingham, Data Sheet Division; H. E. Morton and F. L. Morse, Aeronautic Division; A. C. Bryan, Transmission Division; T. R. Cook (to take the place of R. J. Nightingale), Starting Battery Division; J. T. R. Bell, Ball and Roller Bearings Division; and C. C. Hinkley, Engine Division.

The constitution adopted by the S. A. E. Student Branch at the Michigan Agricultural College was approved, this having been passed on favorably by the Section Committee.

It was voted that Councilor H. L. Horning and K. W. Zimmerschied be added to the Preparedness Committee.

It was suggested that the Council should deprecate the tendency to discontinue or curtail work in scientific and engineering education and research on account of war conditions. It was the sense of the Council that promising students in science and engineering should be encouraged to continue their scholastic training, and that steps should be taken to stimulate research work.

Applications *for* Membership

A list of current applications for membership is given below. The members are urged to send any pertinent information with regard to those whose names are given which the Council should have for consideration prior to their election. It is requested that such communications from members should be sent promptly.

ACKER, EMIL W., sales engineer, Sheldon Axle & Spring Co., *Wilkes-Barre, Pa.*
ANDERSON, DOUGLAS G., president, general manager, Cyclemotor Corp., *Rochester, N. Y.*
AUGENSTEIN, W. C., JR., sales engineer, Vesta Accumulator Co., *Chicago.*

BASSETT, WILLIAM H., technical superintendent, metallurgist, American Brass Co., *Waterbury, Conn.*
BELKNAP, FRANK L., patent counsel, Gillette Motors Co., Mishawaka, Ind., and Whittier Co., *Chicago.*
BENSON, BYRON D., assistant treasurer, Tidewater Oil Co., vice-president, Platt & Washburn Refining Co., *New York.*
BIJUR, HARRY, inspection manager, Trego Motors Corp., *New Haven, Conn.*
BLAKESLEE, C. J., assistant chief engineer, Woods Motor Vehicle Co., *Chicago.*
BONHAM, WALTER R., sales manager, Triumph Electric Co., *Chicago.*
BOURQUARDEZ, A. C., sales manager, General Vehicle Co., *Long Island City, N. Y.*
BRATE, HARRY R., secretary, National Gas Engine Association, *Lakemont, N. Y.*
BREEZE, ALFRED B., vice-president, The Cincinnati Ball Crank Co., *Cincinnati, Ohio.*
BREITSCHMID, OTTO, assistant service manager, Bosch Magneto Co., *New York.*
BROOKMAN, LOUIS, advertising representative, The Commercial Vehicle, *Chicago.*

CAMPBELL, ALFRED L., designer, Brewster & Co., *Long Island City, N. Y.*
CAMPBELL, LEON J., chief engineer, Campbell Transmission Co., *Buchanan, Mich.*
CAPRON, W. A., captain, Field Artillery, U. S. A., *Washington, D. C.*
CARHART, GEORGE COOK, designing engineer, Brown Lipe Gear Co., *Syracuse, N. Y.*
CARLAW, ROBERT H., manager motor department, David Carlaw & Sons, *Glasgow, Scotland.*
CARR, ROBERT L., truck sales engineer, Dorris Motor Car Co., *St. Louis, Mo.*
CHAPMAN, ROBERT H., assistant, engineering laboratories, Locomobile Company of America, *Bridgeport, Conn.*
COATES, A. H., proprietor of sales company, *San Francisco, Cal.*
COGGESHALL, GEORGE W., chemical engineer in charge, The Institute of Industrial Research, *Washington, D. C.*
CONNOR, WILLIAM L., vice-president, general manager, engineer, Rennoc-Leslie Motor Co., *Philadelphia.*

DASHIELL, WILLIAM W., president, N. Y. Lubricating Oil Co., *New York.*
DE LA GRANGE, AMAURY, captain, French Flying Corps, *Washington, D. C.*
DIFFIN, CHARLES W., assistant to president, Erie Specialty Co., *Erie, Pa.*
DUBBS, CARBON P., consulting petroleum expert, Universal Oil Products Co., *Wilmette, Ill.*
DUNN, E. J., president, Eclipse Machine Co., *Elmira, N. Y.*
DU PNE', WALLACE D., assistant statistician, truck division, The Locomobile Co. of America, *Bridgeport, Conn.*

EIGHMEY, DAVID T., designer, Emerson Motors Co., *Kingston, N. Y.*
EVANS, POWELL, president, Merchant & Evans Co., *Philadelphia.*

FALLERIUS, HENRY GUSTAVE, mechanical and electrical engineer, American Express Co., *Mamaroneck, N. Y.*
FOWLER, HARLAN D., aeronautical engineer, Aviation Section, Signal Corps, *Mineola, N. Y.*
FOWLER, ROBERT GEORGE, vice-president, Fowler Airplane Corp., *San Francisco, Cal.*

GAYLORD, LISLE HOWARD, chief draftsman, The Industrial Equipment Co., *San Francisco, Cal.*
GEYER, E. H., sales engineer, Byrne Kingston & Co., and Kokomo Electric Co., *Kokomo, Ind.*
GIBSON, LESTER H., general manager, Higginson-Gibson Mfg. Co., *Boston, Mass.*
GOFF, DOUGLAS C., assistant sales manager, Winther Motor Truck Co., *Kenosha, Wis.*
GREENE, H. S., sales manager, Nungesser Carbon & Battery Works, National Carbon Co., Inc., *Cleveland.*
GROTHE, WALTER, engineer, The C. L. Best Gas Traction Co., *San Leandro, Cal.*
GUTHRIE, H. J., president, Platt & Washburn Refining Co., *New York.*

HADLEY, WALTER K., district sales manager, King Motor Car Co., *New York.*
HAGENLOCHER, C. PAUL, general manager, Wright Roller Bearing Co., *Philadelphia.*
HALL, HENRY J., JR., vice-president, New York Lubricating Oil Co., *New York.*
HARDY, ALEXANDER B. C., vice-president, Chevrolet Motor Co., *New York.*
HARKNESS, ERNEST LESTER, production engineer, airplane engine division, General Vehicle Co., *Long Island City, N. Y.*
HAZELETT, CLARENCE, charge of engineering department, storage battery division, National Carbon Co., *Cleveland.*
HENDERSON, WILLIAM GASTON, vice-president, engineer, Henderson Motorcycle Co., *Detroit.*
HIRTH, LOUIS SEBASTIEN, mechanical draftsman, Walker Vehicle Co., *Chicago.*
HOHENTHAL, ELMER H., sales manager, Simms Magneto Co., *E. Orange, N. J.*
HOOF, ADDISON C., sales engineer, W. K. Prudden Wheel Co., and John C. Hoof & Co., *Chicago.*
HOTZ, GEORGE J., president, manager, engineer, The Hotz Foundry & Mfg. Co., *Fremont, Ohio.*

IDE, ROY W., gas engine designer, A. L. Ide & Sons, *Springfield, Ill.*

JANES, E. H., vice-president, The Standard Steel Castings Co., *New York.*
JONES, DAVID W., chief engineer, Diamond T Motor Car Co., *Chicago.*
JONES, T. A., treasurer, general manager, W. A. Jones Foundry & Machine Co., *Chicago.*

KRATSCH, CHARLES, treasurer, Sumter Electrical Co., *Chicago.*
KUHN, BRADFORD D., manager, technical department, Packard Motor Car Co., *Baltimore, Md.*
KUHSICK, ALBERT J. H., factory superintendent, Edward J. Hartford, Inc., *Jersey City, N. J.*

LACROIX, PAUL, director of sales, Rubay Co., *Cleveland.*
LINDSLEY, HARRY J., sales manager, Bound Brook Oil-less Bearing Co., *Detroit.*
LIPE, WILLARD C., president, Railway Roller Bearing Co., *Syracuse, N. Y.*

MACPHERSON, JAMES W., laboratory engineer, Sphinx Fuel Devices Co., *Brooklyn, N. Y.*
MCALLISTER, WILLIAM I., vice-president, general manager, The Pitter Fan Co., *Chicago.*
MCFARLAND, CHARLES NORMAN, mechanical representative, United Motors Corp., *New York.*
MARGOLIN, GEORGE, engineer, Bosch Magneto Co., *New York.*
MARSCHNER, FERD. W., sales engineer, New Departure Mfg. Co., *Detroit.*
MARTIN, L. J., executive engineer, The B. B. & C. I. Ry. Co., *Bombay, India.*
MEAD, HAROLD G., inspector airplanes and airplane engines, U. S. Government, *Washington, D. C.*
MEARS, B. B., lubrication engineer, Vacuum Oil Co., *New York.*
MESSINGER, WM., engineer, Standard Roller Bearings Co., *Philadelphia.*
MILLER, ALFRED H., engineer, Wright Roller Bearing Co., *Philadelphia.*
MILLER, CLARENCE RUSSEL, personal experimental work, *Cincinnati, Ohio.*
MINGLE, HARRY B., president, Standard Aero Corp., *Plainfield, N. J.*
MORIARTY, GEORGE H., manager of parts and service, Chevrolet Motor Co. of Canada, *Regina, Sask., Can.*
MORRIS, PERCY G. B., chief instructor, American School of Aviation, vice-president, Benoist Aeroplane Co., *Chicago.*

NEGISHI, MASAKAZU, professor of mechanical engineering, Tokyo High Technical College, 25 Madison Ave., *New York.*
NIXON, HENRY S., superintendent, Park Drop Forge Company, *Cleveland.*

O'BRIEN, THOMAS T., factory representative, Willys Overland Inc., *Toledo, Ohio.*
O'HARE, C. B., general sales manager, Aurora Automatic Machinery Co., *Chicago.*

PARSONS, ARTHUR E., general manager, Brown Lipe Gear Co., *Detroit.*
PERRY, GERALD L., aviation mechanic, Seventh Aero Squadron, U. S. A., *Empire, C. Z., Pan.*
PETRY, NICHOLAS ALFRED, president, N. A. Petry Co., Inc., *Philadelphia.*
PRESTON, EDWARD S., vice-president, Chicago Electric Mfg. Co., *Chicago.*

REID, JAMES, superintendent, J. H. Williams & Co., *Buffalo.*
RIORDAN, BERNARD J., general machinery salesman, The Chas. A. Strelinger Co., *Detroit.*
ROETTINGER, HARRY, salesman, The Western Spring & Axle Co., *Detroit.*
ROGERS, RALPH F., president, Rogers Mfg. Co., *Chicago.*
ROSS, OSCAR A., mechanical and electrical engineer, Wright-Martin Aircraft Corp., *New York.*
ROWLANDS, L. S. R., general manager, International Motor Company, *Ottawa, Ont., Can.*
RUBAY, LEON, president, The Rubay Co., *Cleveland.*

SANDERHOFF, ROLAND, engineer, Gray Dort Motors Ltd., Chatham, Ont., Can.
SCHUPP, ARTHUR A., inspector, airplanes and airplane engines, Signal Service at Large, War Department, *Saginaw, Mich.*
SCHWARZ, ELMER H., consulting electrical and mechanical engineer, 160 Broadway, *New York.*
SHIPLEY, S. C., chief mechanical engineer, General Engineering Co., *Detroit.*
SILLIS, WILLIAM C., vice-president, Chevrolet Motor Co. of New York, *New York.*

SLEICHER, RALPH H., sales engineer, Edw. A. Cassidy Co., *New York.*
SOULIS, HAROLD A., chief engineer, Layman Pressed Rod Co., *New York.*
SMITH, KYLE, general manager, Kyle Smith Aircraft Co., *Huntington, W. Va.*
STONEY, MALCOLM P., chief engineer, Merchant & Evans Co., *Philadelphia.*
STRITMATTER, ALBERT, associate editor, *Farm Implement News, Chicago.*
SWEET, HENRY W., engineer, Brown Lipe Gear Co., *Syracuse, N. Y.*
THOMAS, JAY VAN VLECK, assistant sales manager, The F. B. Stearns Co., *Cleveland.*
TILT, CHARLES A., president, Diamond T. Motor Car Co., *Chicago.*
WADE, NATHAN, salesman, Bound Brook Oil-less Bearing Co., *Detroit.*
WALKER, STEPHEN M., gas-engine expert and buyer, Montgomery Ward & Co., *Chicago.*
WALL, FRANK A., secretary-treasurer, general manager, The Brown-Wall Engine & Pulley Co., *Holland, Mich.*
WATSON, HOWARD S., sales and consulting engineer, A. H. Coates' Factory Representative, *San Francisco, Cal.*
WEIDLING, CARL J., engineer, Oneida Motor Truck Co., *Green Bay, Wis.*
WHITE, JOHN WM., JR., chief engineer, Industrial Equipment Co., *San Francisco, Cal.*
WHITEMAN, CLARENCE E., chief designer, V-Plex Ring Co., *Medford, Ore.*
WILSON, HAROLD G., sales engineer, Hyatt Roller Bearing Co., *Detroit.*
WILSON, ROBERT SMITH, manager, solid tire department, Goodyear Tire & Rubber Co., *Akron, Ohio.*
YOUNG, JAMES A., Eastern sales manager, Sheldon Axle & Spring Co., *Wilkes-Barre, Pa.*

Applications *Approved*

The following list of applicants were approved for admission to the Society at the June meeting of the Council. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate; (Aff. Rep.) Affiliate Representative; and (S. E.) Student Enrollment.

ABBOTT, L. H. (A) assistant sales manager, Chase Motor Truck Co., *Syracuse, N. Y.*, (mail) 413 Court St.
ALBAUGH, G. R. (M) Reo Motor Car Co., *Lansing, Mich.*, (mail) 515 Spring St.
ALT, CHAS. S. (A) superintendent, Buffalo Gasolene Motor Co., *Buffalo, N. Y.*, (mail) 280 East St.
AMBROSE, FREDERICK STEWART (M) engineer, The Singer Motor Co., *New York*, (mail) 86 West 16th St., *Bayonne, N. J.*
ANDERSON, WILLIAM C. (A) president, Anderson Engine Co., 4036 N. Rockwell St., *Chicago.*
ANDREWS, DUDLEY (A) road service expert, Premier Motor Corp., *Indianapolis*, (mail) 3446 Graceland Ave.
THE O. ARMLEDER CO. (Aff.) 12th and Plum Sts., *Cincinnati, Ohio.* Representative: C. W. Steele, secretary.
AUSTIN, RALPH W. (Aff. Rep.) chief engineer, The Gramm-Bernstein Motor Truck Co., *Lima, Ohio.*
AVILOV, B. I. (M) managing director, Aksai Machinery Corp., *Rostov-on-Don, Russia.*
BARTLETT, EDWARD C. (J) sales engineer, Wheelock, Lovejoy & Co., Cambridge, Mass, (mail) 8205 Carnegie Ave., *Cleveland.*
BATCHELDER, CHARLES FREDERICK (A) assistant general sales manager, Dort Motor Car Co., *Flint, Mich.*
BAUMGARDNER, JOHN A. (M) metallurgical engineer, Buick Motor Co., *Flint, Mich.*
BEAVER, H. LEROY (A) salesman, Atlas Ball Co., *Philadelphia.*
BECK, MILTON (M) research engineer, Duesenberg Motor Corp., Oakley & Oakdale Sts., *Chicago.*
BEDFORD, EARL A. (J) engineer, United Motors Co., *Grand Rapids, Mich.*
BENNETT, STANLEY RICHARD (A) assistant supervisor, testing department, Bosch Magneto Co., *Springfield, Mass.*, (mail) 1089 Worthington St.
BENTLEY, G. P. (S. E.) University of Michigan, *Ann Arbor, Mich.*, (mail) 621 Forest Ave.
BERLINGHOF, WILLIAM L. (A) service manager, Eisemann Magneto Co., 32 33rd St., *Brooklyn, N. Y.*
BERNO, EDWARD HARMOND (J) draftsman, The Milburn Wagon Co., *Toledo, Ohio*, (mail) 614 S. Main St.
BERRIEN, WM. P. (A) sales manager, The Batavia Rubber Co., *Batavia, N. Y.*, (mail) 39 Ellicott Ave.
BIERMAN, F. H. (A) president, Strite Governor Pulley Co., *Minneapolis*, (mail) 307 3rd St.
BISHOP, HARVEY L. (M) engineer, New Age Tractor Co., 3046 Snelling Ave., *Minneapolis.*
BISHOP, R. P. (A) sales manager, King Motor Car Co., *Detroit.*
BLACKLEY, B. E. (A) general sales manager, Chase Motor Truck Co., *Syracuse, N. Y.*, (mail) P. O. Box 767.
BLAIR, C. A. (J) experimental mechanical engineer, McFarlan Motor Co., *Connersville, Ind.*
BOND, R. W. (A) designer, Inter-State Motor Co., *Muncie, Ind.*, (mail) 428 W. Howard St.
BOND, WALTER DE LA ROCHE (A) commercial manager, rubber department, St. Helens Cable & Rubber Co., Ltd., *Warrington, Eng.* (mail) 48 Grappenhalt Road, Stockton Heath.
BOOTH, FRED C. (J) experimental engineer, Ernest Wooler, *Cleveland* (mail) 10605 Kimberley Ave.
BOWEN, RALPH WILLIAM (A) experimental mechanic, Crow-Elkhart Motor Co., *Elkhart, Ind.*, (mail) 1131 Cossoholis St.
BOWKER, HAROLD G. (A) chief draftsman, Four Wheel Drive Auto Co., *Clintonville, Wis.*
BRANDENBURG, J. I. (A) partner, Brandenburg & Co., *New York.*
BRAYMAN, GEO. A. (A) layout man, Garford Motor Truck Co., *Lima, Ohio*, (mail) 302½ E. Market St.
BROMLEY, WAYNE K. (A) secretary-treasurer, The Pathfinder Co., *Indianapolis.*
BROWN, FREDERICK E. (A) assistant to second vice-president, Shelby Steel Tube Co., 1714 Frick Bldg., *Pittsburgh.*
BROWN, JULIAN STEVENS (M) independent engineer, 619 Woodward Ave., *Detroit.*
BROWN, SANDFORD (A) general sales manager, Condensite Company of America, *Bloomfield, N. J.*
BROWNE, W. J. (A) assistant general superintendent, Buick Motor Co., *Flint, Mich.*, (mail) 552 E. 5th Ave.
BUSKIRK, FRED G. (A) assistant sales manager, The Pathfinder Co., *Indianapolis.*
CADLE, JOHN A. (A) salesman, Willard Storage Battery Co., *Cleveland.*
CALLANAN, EDWARD AGNEW (A) assistant branch manager, Willys-Overland Inc., *St. Paul, Minn.*
CAMMEN, LEON (M) associate editor, American Society of Mechanical Engineers, *New York.*
CARLTON, C. C. (M) general sales manager, rim department, Prudden Wheel Co., *Lansing, Mich.*
CASWELL, SYDNEY C. (A) manager Eastern office, National Lamp Works of General Electric Co., *New York.*
CASWELL, WALTER H. (A) superintendent, wholesale department, Ford Motor Co., Long Island City, (mail) 106 W. 69th St., *New York.*
CECIL, CLIFFORD BUCHANAN (J) chief chemist, Warner Gear Co., *Muncie, Ind.*, (mail) 515 Hutchinson Ave.
CHACE, ARTHUR B. (A) factory manager, Splitdorf Electrical Co., *Newark, N. J.*
CHAMBERS, HARRISON W. (A) general foreman automobile service, The Milwaukee Electric Railway & Light Co., *Milwaukee, Wis.*
CHANDLER, M. E. (J) laboratory engineer, Stromberg Motor Devices Co., *Chicago.*
CHARLTON, KENNETH R. (A) president, K. R. Charlton, Inc., *Holyoke, Mass.*
CHASE, IRWIN, (M) naval architect, Elco Co., *Bayonne, N. J.*
CHILDS, WILL P. (M) engineer, Falls Motor Corp., *Sheboygan Falls, Wis.* (mail) Lock Box 3.
CHRISTEN, JOSEPH C. (A) advisory engineer, Dura Mechanical Hardware Co., *Toledo, Ohio.*
CHRISTENSEN, H. W. (M) chief engineer, The Sayers & Scovill Co., *Cincinnati, Ohio.*
CHURCH, H. A. (A) secretary-treasurer, King Motor Car Co., *Detroit.*
CHURCHILL, WILLIAM (M) sales manager, Corning Glass Works, *Corning, N. Y.*
CLANCY, C. EUGENE (A) manager parts and order department, Chevrolet Motor Co. of Minnesota, *Minneapolis*, (mail) 427 Beacon Ave., St. Paul, Minn.
COLLINS, ARTHUR L. (J) engineer of tests, Atlas Ball Co., *Philadelphia.*
COLLINS, KENNETH G. (J) U. S. Aviation School, *Ithaca, N. Y.*
COLVARD, S. W. (J) mechanical engineer, Service Motor Truck Co., *Wabash, Ind.*, (mail) 340 N. Wabash St.
COMPTON, LEWIS R. (M) general manager, Lewis R. Compton & Co., *New York.*
CONANT, EARL DALE (A) superintendent, The Buda Co., *Harvey, Ill.*, (mail) 153 155th St.
COOK, OTIS RICHMOND (A) general sales manager, Kelly-Springfield Tire Co., *Cleveland.*
COOKSEY, DONALD (J) teacher of physics, Yale University, New Haven, Conn., (mail) 104 Huntington St.
COOPER, W. O. (A) general manager, Templer Motors Corp., *Cleveland.*
COPLESTON, H. (M) assistant engineer, H. W. Johns-Manville Co., *New York.*
CORCORAN, EDWARD STEPHEN (S. E.) Sibley College, Cornell University, Ithaca, N. Y., (mail) 267 S. Clairmont Ave., *Springfield, Ohio.*
CORMACK, GEO. (M) superintendent, tractor department, Appleton Mfg. Co., *Batavia, Ill.*
CORWIN, LLOYD A., (A) efficiency engineer, Four Wheel Drive Auto Co., *Clintonville, Wis.*

CRIDER, JOSEPH E. (A) sole owner and manager, The Water Craft Co., *New York.*

CROCKETT, C. H. (M) research engineer, *Troy, N. Y.*

CROSBIE, DANIEL L. (A) experimental engineer, The Kelly-Springfield Motor Truck Co., *Springfield, Ohio.*

CROW, HAROLD IRA (J) layout draftsman, Mercer Automobile Co., *Trenton, N. J.*, (mail) 17 Ewing St.

CUSHING, THURBER W. (A) vice-president of sales and advertising, Maibohm Motors Co., *Racine, Wis.*

DABNEY, H. D. (A) office manager, Society of Automotive Engineers, *New York.*

DAUBNER, GEO. H. (A) chief engineer, Barley Motor Car Co., *Kalamazoo, Mich.* (mail) 515 Reed St.

DEE, SIMON R. (A) vice-president, Harvey Motor Truck Co., *Harvey, Ill.*

DENIS, GEORGE E. (A) draftsman, Duesenberg Motor Corp., *Edgewater, N. J.*

DENTON, I. H. (A) direct representative, Ohio Seamless Tube Co., Ohio Forge Co., Dahlstrom Metallic Door Co., Cumberland Steel Co., 1017 Engineers Bldg., *Cleveland.*

DEVLIEG, RAY A. (M) chief draftsman, Dodge Bros., *Detroit*, (mail) 1031 E. Grand Boulevard.

DEVOE, B. H. (J) instructor in mechanical drawing, Purdue University, *West Lafayette, Ind.*, (mail) 427 Wood St.

DEWEY, DONALD MACK (M) detailer, Winther Motor Truck Co., Kenosha, Wis., (mail) *Wanwatora, Wis.*

DIMOND, G. ARNOLD (A) president, Singer Motor Co., Inc., *New York.*

DIPPY, ROBERT NEWTON (A) service manager, Atwater Kent Mfg. Works, 4837 Stenton Ave., *Philadelphia.*

DIXON, OTTO (A) tool supervisor, Premier Motor Co., *Indianapolis*, (mail) 543 North Temple Ave.

DOST, CHARLES OTTO (A) chief engineer, Williams Motor Co., *Waukegan, Ill.*, (mail) 912 N. Sheridan Road.

DOUGLAS, DONALD W. (J) aeronautical engineer, Aviation Section, Signal Corps, *Washington, D. C.*

DUCKWORTH, CLARENCE H. (M) chief engineer, Doehler Die Casting Co., *Brooklyn, N. Y.*

DUESENBERG, AUGUST S. (M) assistant engineer, Duesenberg Motors Corp., *Edgewater, N. J.*

DU[illegible], [illegible] (A) general manager, Bailey Non-Stall Differential Corp., *Chicago.*

DU MONT, FREDERIC J. (A) branch manager, Willard Storage Battery Co., *New York.*

DUNLER[illegible], LORIMER (A) service manager, Duesenberg Motors Corp., *New York.*

EATON, R. T. (A) master mechanic, Atwater Kent Mfg. Works, Philadelphia, (mail) 508 Westview Ave., *Germantown, Pa.*

EDWARDS, JAMES M. (A) charge of experimental department, Associated Mfg. Co., *Waterloo, Iowa.*

EDWARDS, WILLIAM A. (A) manager, Michigan Steel Exchange, Inc., Goebel Bldg., *Detroit*, (mail) 33 State St.

ELLIS, W. P. (A) factory manager, Stromberg Motor Devices Co., *Chicago*, (mail) 6042 St. Lawrence Ave.

EMMERT, ARTHUR P. (A) assistant general superintendent, Warner Gear Co., *Muncie, Ind.*

ENDEBROCK, J. C. (A) secretary, The Sechler & Co., *Cincinnati, Ohio.*

ERICSON, F. G. (M) chief engineer, Canadian Aeroplanes, Ltd., Dufferin St. and Lappan Ave., *Toronto, Can.*

EVANS, GORDON M. (M) general manager, Menominee Motor Truck Co., *Menominee, Mich.*, (mail) 1411 Main St.

FERRY, PHILLIPS B. (A) designer of airplanes, Wright-Martin Aircraft Corp., *New York.*

FERGUSON, SAM (A) inspector, Maxwell Motor Co., *New Castle, Ind.*

FINDEISEN, RAYMOND (A) assistant in production department, Findeisen & Kropf Mfg. Co., Chicago, (mail) 3101 Harlem Ave., *Berwyn, Ill.*

FINKENSTAEDT, HARRY S. (A) district sales manager, Carbon Steel Co., Pittsburgh, (mail) 1852 Penobscot Bldg., *Detroit.*

FINUCANE, JOHN JOSEPH (A) experimental engineer, Cyclemotor Corp., Brighton Station R. F. D. No. 1, *Rochester, N. Y.*

FLATHER, DAVID (M) director, W. T. Flather, Ltd., *Sheffield, Eng.*

FLATHER, G. D. (M) director, W. T. Flather, Ltd., Sheffield, Eng., (mail) Standard Steel Works.

FLIEDNER, CARLYLE S. (M) editor, Electricity Magazine, *Chicago.*

FOSS, W. J. (A) second vice-president, The Pierce Arrow Motor Car Corp., 1695 Elmwood Ave., *Buffalo.*

FOX, RUDOLPH H. (M) experimental engineer, Fafnir Bearing Co., *Hartford, Conn.*

FRANTZ, J. R. (M) vice-president, LeRoi Co., Milwaukee, Wis., (mail) 664 73rd Ave., *West Allis, Wis.*

FRENCH, HERBERT JAMES (J) metallurgist, General Vehicle Co., Inc., *Long Island City, N. Y.*

FRINK, MILTON D. (A) field service man, Anderson Motor Co., *Rock Hill, S. C.*

FROELICH, OSCAR E. H. (A) engineering inspector, Ward Motor Vehicle Co., Mount Vernon, N. Y., (mail) 593 Madison St., *Brooklyn, N. Y.*

FROST, A. H. (M) chief engineer, Van Blerck Motor Co., 401 N. Macomb St., *Monroe, Mich.*

GALLIMORE, KEITH FRANCIS (M) assistant chief engineer, Van Blerck Motor Co., *Monroe, Mich.*, (mail) Lock Box 143.

GARDNER, C. F. (A) factory manager, The Kelly-Springfield Motor Truck Co., *Akron, Ohio.*

GARMAN, H. B. (A) superintendent, Michigan Electric Welding Plant, *Detroit.*

GEARHART, J. A. (A) treasurer, Gulick-Henderson Co., *Pittsburgh.*

GALLATLY, E. S. (A) vice-president, Indian Refining Co., 44 Whitehall St., *New York.*

GELZER, J. A. (A) sales engineer, Wagner Electric Mfg. Co., St. Louis, Mo., (mail) 918 Michigan Ave., *Chicago.*

GENERAL BAKELITE Co., (Aff. Mem.) *New York.* Representatives: Herbert S. May, manager, Hylton Swan, sales engineer.

GERHARDT, W. FREDERICK (S. E.) University of Michigan, *Ann Arbor, Mich.*, (mail) 515 E. Jefferson St.

GIFFORD, FRANKLIN (A) draftsman, Bijur Motor Lighting Co., Hoboken, N. J., (mail) 529 Van Vorst Place, *Weehawken, N. J.*

GILLIGAN, FRANK P. (M) secretary-treasurer, The Henry Souther Engineering Co., *Hartford, Conn.*, (mail) 11 Laurel St.

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